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In This Issue:

The Largest American Solar Furnace

World's Astronomers Meet in Moscow

Boston's Planetarium Opens

American Astronomers Report

The Chemical Composition and Ages of Stars

The New IAU Nomenclature for Mars

Among Southern Galaxies — X

Stars for November

Vol. XVIII, No. 1

NOVEMBER, 1958

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Sky and TELESCOPE

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Submarine and Space Medicine Symposium

TWO HUNDRED scientists, invited from nine countries, attended the first gathering of its kind at the U. S. Submarine Base, New London, Connecticut, on September 8-12. The first international symposium on submarine and space medicine was sponsored by the American Institute of Biological Sciences and the Department of Defense.

The meeting's purpose was to stimulate physiological research dealing with interplanetary travel. Its participants wished for closer working relations with scientists in other fields. While agreeing that spaceflight is possible, they disagreed with engineers who state that all required information can be relayed to the earth from space by unmanned satellites.

It is apparent that man must take his earth environment into space by sealed-cabin flight. Many of the physiological problems are those of travel by submarine, but with additional complications. The Navy showed movies of an aluminum sphere of the sealed-cabin type used to carry one man to altitudes of about 90,000 feet for special studies. It was designed over 10 years ago.

Scores of research reports were presented, on topics including the effect of rotation of the earth upon a subject's metabolism and performance of work, and effects of spaceflight on circulation of the blood to the heart, lungs, and brain. Lt. Col. David G. Simons told about his flight of August, 1957, into the stratosphere, when a height of over 100,000 feet was reached. He described how he experienced the "breakoff" phenomenon, a peculiar feeling of well-being and buoyancy, in which the space traveler has a strong disinclination to return to earth; similar partial separation occurs among persons pursuing certain atavistic forms of meditation. The breakoff is not due to the toxic effect of breathing too much carbon dioxide.

Both the submariners and astronauts were concerned with the toxicological problems of confined spaces – carbon-monoxide and ozone poisoning, and the effects of condensation droplets.

A new strain of fast-multiplying algae was described that can supply oxygen continuously for one man in spaceflight. The required volume for both the growing tank and the light source necessary for propagation of the algae is less than five cubic feet.

Participants in the conference gained a keen awareness that vast changes in man's experience of life are in the making, even more profound than those of Renaissance man.

HOWARD LASKEY, M.D.
Carolina, R. I.

A high-angle view of the U. S. Army's new solar furnace, located on the shore of Lake Cochituate, Massachusetts. From the steerable heliostat, at the right, sunlight is reflected to the concentrator at the left, which focuses it into the test chamber at center. The attenuator is almost open here, while in the view on the front cover its shutters are almost closed.

The Largest American Solar Furnace

MANY useful purposes can be served by solar furnaces – from cooking food to testing materials intended to withstand an atomic blast. The latter is the reason for the building of America's largest solar furnace, at Natick, Massachusetts, on the wooded shore of Lake Cochituate. It is part of the U. S. Army's Quartermaster Research and Engineering Center.

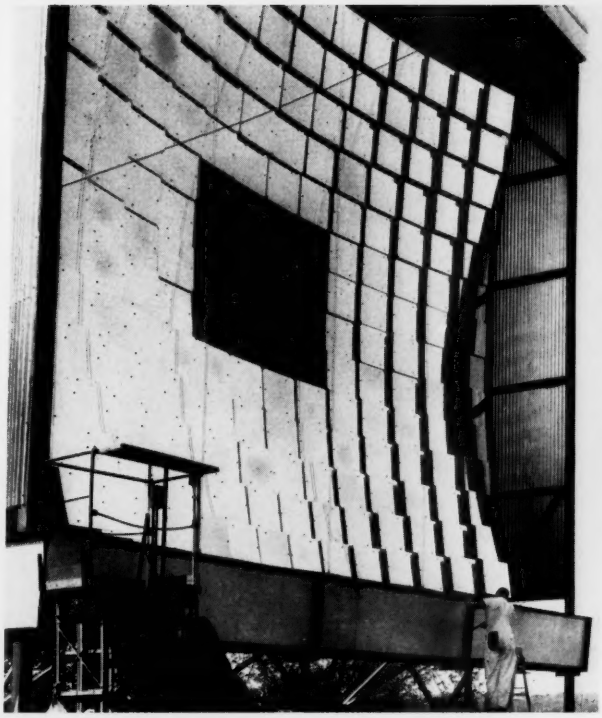
This is the same instrument whose preliminary plans were described in *Sky and Telescope* for May, 1957, page 332. Its completion was celebrated by a formal dedication on September 30, 1958, followed by a two-day symposium at which experts discussed many aspects of the utilization of energy from the sun.

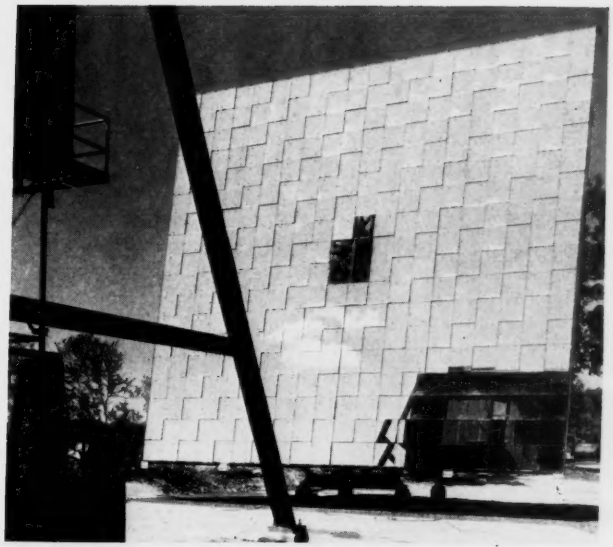
Located 17 miles west of Boston, the $275,000 apparatus occupies a ground area 125 by 40 feet. It is the first large furnace of the focusing type to utilize an effective focal ratio of less than one, and will furnish much valuable information on the effects of high-intensity thermal radiation on materials.

The Natick installation is not a furnace in the ordinary sense; it is not a means for maintaining a sustained high temperature, but instead provides short pulses of extremely intense heat radiation – similar to those of atomic-bomb blasts. Thus the furnace is a convenient and economical device for testing Army protective materials before actual field trials.

The Quartermaster Corps engineers

Photographs taken during an operational test with the Natick solar furnace show a heavy piece of iron before, during, and after being subjected to the four-inch-wide beam of concentrated solar radiation, which burned through the ¼-inch-thick metal in only one second.





Above: The 36-foot-high heliostat, which can follow the sun in altitude and azimuth, with its 355 plate-glass mirrors.

Left: A workman at bottom right is dwarfed by the concentrator's 180 concave mirrors. They form an over-all effective surface that acts as a paraboloid.

found the sun to be the most suitable available source of intense thermal radiation. Other sources, such as gas flames or electric arcs, are either too cool or generate heat over too small an area. With the adopted design, a blast of heat reaching nearly 5,000° Fahrenheit can be obtained over a circle four inches in diameter.

There are four main parts to the solar furnace: heliostat, attenuator, concentrator, and test chamber. Sunlight is first collected by the heliostat, an array of 355 mirrors, each two-feet square and $\frac{1}{4}$-inch thick, placed so they act as a single large plane mirror. This array is square rather than circular, as in the case of the large furnace at Montlouis in France.

The aluminum heliostat framework, 36 feet high and 40 feet wide, can track the sun both in altitude and azimuth. A similar mounting design has been used by the builders, D. S. Kennedy and Co., for some of their radio telescopes and radar antennas. On the longest day of the year, up to eight hours of operation are possible.

From the heliostat sunlight passes through the attenuator, a Venetian-blind arrangement to control the amount of radiation reaching the concentrator. The 17 shutter slats close automatically in case of power failure, incorrect tracking, or other emergency.

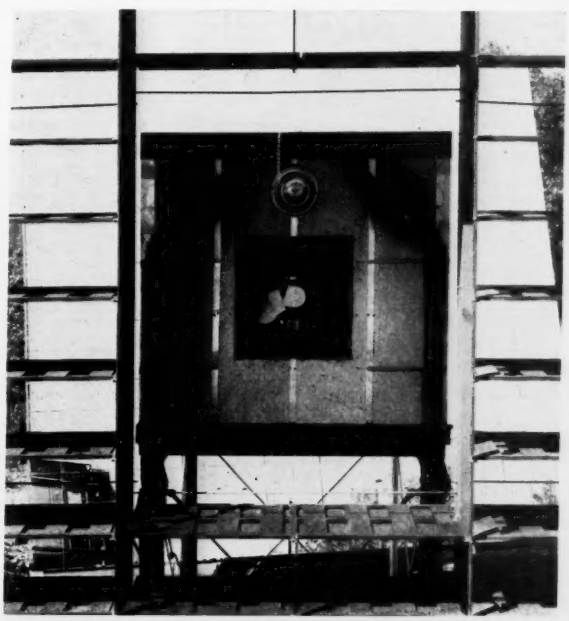
Next the solar beam strikes the concentrator, a concave spherical frame supporting 180 mirrors, also two-feet square and $\frac{1}{4}$-inch in thickness. These concave mirrors are spherical, of 35.8 feet focal length. Their effective area is 710 square feet.

Not only is it much cheaper to use such a mosaic of many small mirrors than it is to make a single surface, but the mirrors can be adjusted individually to minimize aberrations. Thus, at the focus of the concentrator the solar image is about four inches in diameter, with a uniform intensity of about 90 calories per square centimeter each second, corresponding to a total power of 27 kilowatts.

The test chamber has an eight-foot square face and is 16 feet long. Inside are holders for samples, the heliostat and attenuator controls, and measuring devices to record test results. Just before a test begins, a water-cooled protective shutter is opened. The exposure of the sample is provided by a second, high-speed shutter, also water-cooled, which can be opened for as little as 0.1 second.

The lakeside site offers a clear western horizon, and the surrounding woods give good protection from winds, though the installation is designed to withstand hurricane velocities.

From the technological viewpoint, perhaps the most significant feature of the Natick furnace is the effective use of small, mass-produced mirrors for concentrating sunlight, a method that will facilitate the future large-scale exploitation of solar energy.



The eight-foot-high test chamber, mounted behind the opening in the shuttered attenuator. Seen here, in the end facing the concentrator, is the aperture through which the intense beam enters. In the background, part of the heliostat may be seen through the Venetian-blind-type vanes of the attenuator, opened here to their full horizontal position. All photographs with this article are by the U. S. Army.

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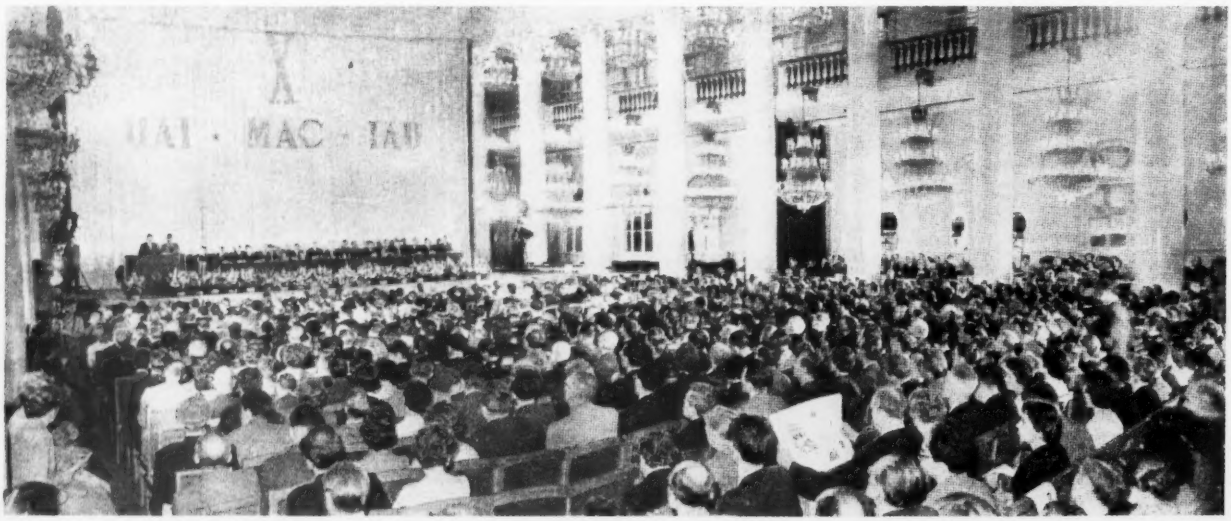
Газета организационного комитета 10-го съезда Международного Астрономического Союза

Gazette du Comité d'Organisation de la X-me Assemblée Générale de l'Union Astronomique Internationale

Newspaper of the Organizing Committee for the Xth General Assembly of the International Astronomical Union



Торжественное открытие 10-го съезда Международного Астрономического Союза

Inauguration solennelle de la X-e Assemblée générale de l'Union Astronomique Internationale

Grand Opening of the Xth General Assembly of the International Astronomical Union

12 августа состоялось торжественное открытие съезда в Колонном зале Дома союзов. В зале присутствуют делегации из 35 стран.

7 часов вечера. Глава советской делегации председатель Астрономического совета Академии наук СССР профессор **А. А. Михайлов** объявляет X съезд открытым.

На трибуне — Заместитель Председателя Совета Министров СССР **А. Н. Косыгин.** По поручению Советского Правительства он приветствует участников съезда и гостей.

— Правительство Советского Союза,— сказал А. Н. Косыгин,— придает большое значение международному сотрудничеству ученых.

А. Н. Косыгин от имени Советского Правительства пожелал участникам съезда плодотворной работы и выразил уверенность в том, что их совместная деятельность будет способствовать развитию дружеских отношений между учеными всех стран, укреплению мира во всем мире.

Грандиозным успехом астрономии и, в первую очередь, советской астрономии посвящена приветственная речь Президента Международного астрономического союза профессора **А. Данжона.**

— Нынешний Международный съезд,— говорит он,— происходит меньше чем через год после грандиозного эксперимента — запуска первого советского искусственного спутника Земли. Эта дата отныне вписана золотыми буквами в число великих событий мировой истории.

Академик **А. В. Топчиев,** вице-президент Академии наук СССР, в своем приветствии главное внимание уделяет развитию международных научных связей. Контакты и связи деятелей советской науки с зарубежными учеными растут с каждым годом.

К своим советским и зарубежным коллегам обращается известный астроном академик **В. А. Амбарцумян.** Он говорит, что астрономия своими успехами в весьма значительной части обязана международному научному сотрудничеству ученых разных стран.

По мнению академика Амбарцумяна, ученые подошли сейчас к такому этапу развития астрофизики, когда перед ними раскрываются новые свойства материи, которые до сих пор не могли быть вскрыты на основе экспериментов в земных лабораториях.

Торжественный вечер закончился большим **вокально-симфоническим концертом.**

* * *

Вчера 13 августа в 9 часов утра в Актовом зале Московского Университета открылось пленарное заседание X съезда МАС. Открывая заседание, Президент МАС проф. А. Данжон предложил почтить вставанием память скончавшихся после IX съезда 28 членов Союза.

На заседании оглашено приветственное письмо бывшего Президента МАС О. Струве. Принят текст ответной телеграммы.

Заслушан отчет Генерального секретаря МАС П. Остерхофа.

В 2 часа дня началась Объединенная дискуссия по астрономическим наблюдениям с искусственных спутников Земли, ракет и баллонов.

Одновременно происходили заседания **Финансового комитета и Объединенной комиссии по спектроскопии.**

The Xth General Assembly of the International Astronomical Union opened August 12 in the Column Hall of the House of Trade Unions, Moscow. Present at the opening were delegations from 35 countries.

7:00 PM. The Head of the Soviet delegation, Chairman of the Astronomical Council of the Academy of Sciences of the USSR, Professor **A. A. Mikhailov** announces the opening of the Xth General Assembly.

A. N. Kossigin, Vice Chairman of the Soviet of Ministers of the USSR, mounts the rostrum. On behalf of the Soviet Government he greets the participants and guests of the General Assembly.

— The Government of the Soviet Union,—said A. N. Kossigin,—attaches great importance to the international co-operation of scientists.

On behalf of the Soviet Government A. N. Kossigin wishes the participants of the General Assembly fruitful results of their work and expresses the conviction that their joint activity will be an aid in both the development of friendly relations among scientists of all countries and the strengthening of peace throughout the world.

The speech of welcome of the President of the International Astronomical Union, Professor **A. Danjon** was inspired by the grandiose successes achieved by astronomy, and especially by Soviet astronomy. The present International General Assembly is held less than one year from the epoch-making expariment—the launching of the first Soviet artificial Sputnik of the Earth, the date, which is inscribed in Golden Letters in the annals of history.

Academician **A. V. Topchiev**, Vice President of the Academy of Sciences of the USSR, in his speech of greetings invited the attention of the delegates chiefly to the consideration of the development of international scientific connections.

Contacts and connections of Soviet men of science with their foreign colleagues are growing from year to year.

The well known astronomer, the academician **V. A. Ambartsumian** greets his Soviet and foreign colleagues. He said that the successes of astronomy were to a large extent made possible by the international scientific cooperation of scientists of many countries.

In the opinion of the academician V. A. Ambartsumian, the scientists have now reached such a stage in the development of astrophysics, when we stand before the discovery of such new properties of matter, which up to now could not have been revealed on the basis of experiments made in terrestrial laboratories.

The Grand Evening was concludad with a large Vocal-Symphonic Concert.

* * *

The plenary session of the Xth General Assembly of the International Astronomical Union opened yesterday, August 13, at 9:00 AM, at the Moscow University.

Opening the session, Professor Danjon proposed to honour the memory of 28 deceased members of the IAU.

A letter of former president Struve was read. He sent his greetings and best wishes for a successful meeting.

General Secretary Oosterhoff made a report.

At 2 o'clock began the discussion on sputniks, rockets and balloons.

L'ouverture solennelle du X-ème Congrès Astronomique a eu lieu le 12 août dans la Salle des Colonnes, en présence des délégués de 35 pays.

Sept heures du soir. Le chef de la délégation Soviétique président du Conseil Astronomique de l'Académie des Sciences de l'URSS professeur **A. A. Mikhailov** annonce l'inauguration de la X-e Assemblée.

Le remplaçant du Président du Conseil des Ministres de l'URSS **A. N. Kossyguine** monte sur la chaire. Il adresse des paroles de bienvenue aux participants et aux hôtes de l'Assemblée de la part du Gouvernement Soviétique.

—Le Gouvernement Soviétique—dit A. N. Kossyguine — attache une grande importance à la collaboration internationale des savants.

N. A. Kossyguine a souhaité de la part du Gouvernement Soviétique aux participants de l'Assemblée du succès dans leur travail; il a exprimé l'espoir que leur activité réunie servira au développement des relations amicales entre les savants de tous les pays, et à la consolidation de la paix dans le monde entier.

Le discours du Professeur Danjon, Président de l' U.A.I. a marqué les grands progrès de l'astronomie. La X-e Assemblée se tient un an après l'expériment magnifique du lancement du premier satellite artificiel. Cette date sera inscrite en lettres d'or au nombre des grandes découvertes de l'histoire universelle.

L'académicien **A. V. Toptchiev,** vice-président de l'Académie des Sciences de l'URSS souligne dans son discours la nécessité du développement des liens scientifiques internationaux.

Les rapports et les relations des représentants de la science soviétique avec les savants étrangers se développent chaque année davantage.

L'académicien **V. A. Ambartsoumian** s'adresse ensuite à ses collègues soviétiques et étrangers. Il souligne que l'astronomie est redevable de ses succès à la collaboration des savants de différents pays.

L'académicien Ambartsoumian pense que les savants sont arrivés à une étape du développement de l'astrophysique qui permet de découvrir de nouvelles propriétés de la matière; ces propriétés ne pouvaient être révélées par des expériments de laboratoires terrestres.

L'inauguration solennelle s'est terminée par un grand Concert.

* * *

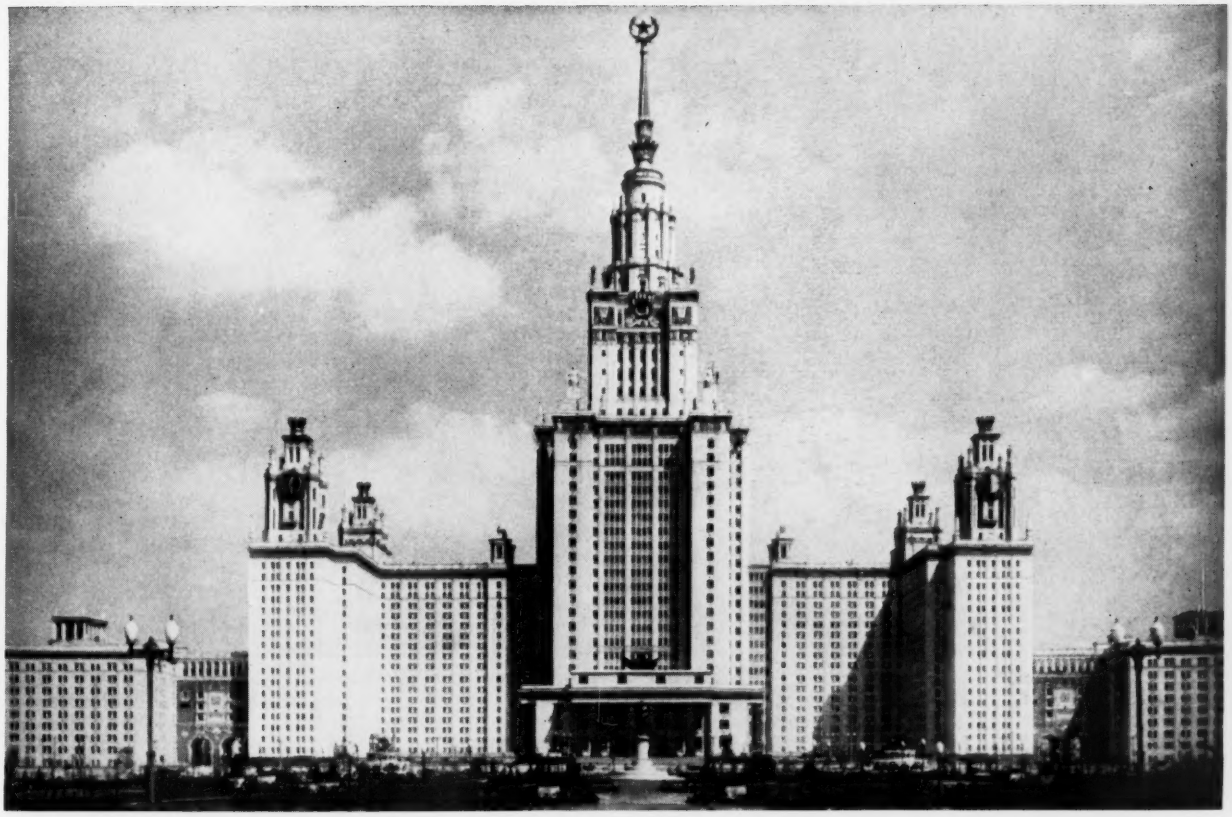
Le 13 août à 9h. du matin dans la Salle des Actes de l'Université de Moscou a eu lieu l'ouverture de la Séance plénière de la X-e Assemblée de l'UAI. Le Président de l'UAI, prof. A. Danjon a invité à honorer la mémoire de 28 membres de l'Union, décédés après la IX-e Assemblée, en se levant.

On a communiqué ensuite la lettre de compliment d'Ex-Président de l'UAI O. Struve.

Le secrétaire général de l'UAI le prof. P. Th Oosterhoff a fait son rapport.

La discussion unifiée sur l'observation astronomique des satellites artificiels de la Terre, des fusées et des ballons a eu lieu à 14 heures.

Des séances du Comité Financière et de la Commission unie de spectroscopie ont eu lieu simultanément.



The meeting place for the International Astronomical Union in 1958 was this new 32-story main building of Moscow University. It is located on high land in a southwestern suburb of Moscow, facing northeastward across the winding Moscow River toward the Kremlin, about four miles away. This is one of 37 buildings of the university.

World's Astronomers Meet in Moscow

BART J. BOK, *Mount Stromlo Observatory, Australian National University*

FROM August 12th to 20th, 1958, I was one of the thousand astronomers from all parts of the world who attended the 10th congress of the International Astronomical Union in Moscow. Now, while returning to Australia, I am writing this report on board the *Pobeda*, a beautiful white passenger vessel that crosses the Black Sea from Odessa to Istanbul.

FACING PICTURE: For the thousand astronomers who gathered in Moscow as guests of the Soviet Academy of Sciences, a special trilingual newspaper was published. This page, reproduced in facsimile, describes the opening ceremonies of the convention, which featured a symphony concert. Other social events during the eight days of the meetings included receptions at the Kremlin and at the embassies of the 35 nations represented. The newspaper featured articles on astronomical research by astronomers from many parts of the world.

The International Astronomical Union was still a small, compact organization when I attended my first meeting, at Leiden, Holland, in 1928. The commissions — there are about 40 — were effective working committees, each with a relatively small membership. We became alarmed when one commission, that on solar phenomena, grew to 40 members. Today, despite constant efforts to prune, some have memberships of between 70 and 80.

The Moscow congress will probably be remembered as the one at which the most effective pruning was done, though most of our commissions remain rather large. But I feel that the nominating committee, on which I represented Australia, made very few appointments of young astronomers to commissions. If the sound policy of keeping these groups small continues, rotating memberships should be instituted.

Congresses of the IAU feature, along with the commission meetings, a series of scientific symposia. At Moscow there were two major symposia, one dealing with the Hertzsprung-Russell diagram, the other with the earth's rotation and the associated problems of atomic time standards. Joint discussions, which were symposia in all but name, dealt with solar flares; artificial satellites, rockets, and balloons; luminosities of Cepheids; and the formation of chemical elements in the stars.

Attendance at these sessions varied from 300 to 1,000. Each person in the audience was provided with a portable radio and headphones, to allow the speaker to be heard in translation, if necessary. In spite of this effort, the symposia seemed the least satisfactory part of the congress. The professional translators performed marvelously, but the essence of the original presentation was lost. I preferred the brief summarizing translations by astronomers well versed in the subject matter, given just after each paper.

Furthermore, the large size of the audiences defeated the very purposes for which a symposium is held: discussion and a

Symposium sessions such as this were held in the second-floor auditorium of the main university building. Out of this picture in the right background were the three large soundproof booths for interpreters; through their radio headphones the audience could follow proceedings in English, French, or Russian.

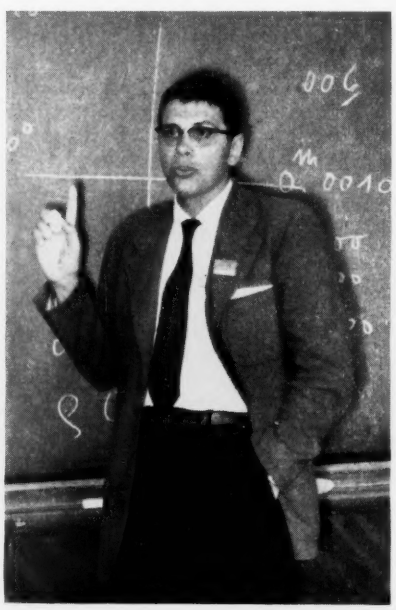
meeting of minds. At Dublin in 1955 we still had some good arguments from the floor, but these were lacking at Moscow. I think the IAU should in the future emphasize smaller symposia — along the lines of the Paris symposium on radio astronomy — held during the fortnight preceding the big congress.

For an astronomer like myself, primarily interested in Milky Way research and stellar evolution, there was much to learn. To illustrate the richness of the fare set before us, I select some items of particular interest in these fields.

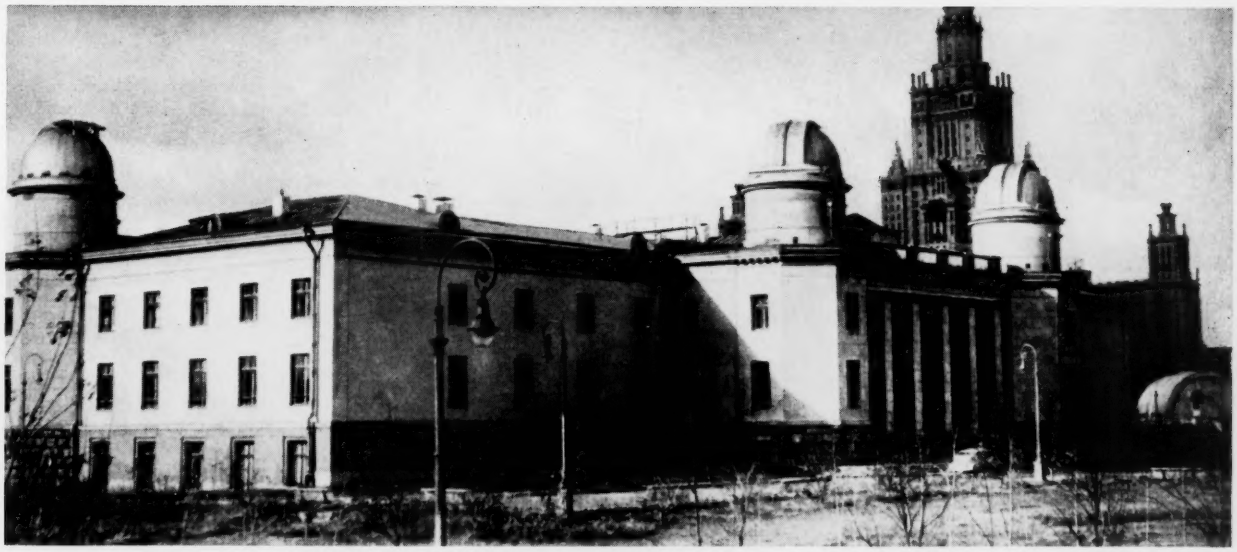
New Galactic Pole. Milky Way astronomers will long remember the Moscow congress as the occasion when workers in this field decided by popular vote (with a little gentle prodding!) to adopt a different position for the galactic pole from that used over the past quarter of a century. (As the problem was described by Otto Struve in last month's *Sky and Telescope,* only the highlights need be mentioned here.)

In 1932 the IAU had officially adopted for the position of the north pole of the Milky Way right ascension $12^h\ 40^m$, declination $+28°$ (1900 co-ordinates). Soon after, the Swedish astronomer J. Ohlsson published very useful tables for the conversion of right ascension and declination into galactic co-ordinates. During the last decade, however, it has become increasingly apparent that the adopted galactic pole is in error by about a degree and a

Left: H. Beck of the Carl Zeiss works, Jena, East Germany, explains to R. d'E. Atkinson (left), Herstmonceux, England, the operation of a large double refractor that his firm is constructing for China. Almost completed is a Zeiss two-meter (79-inch) reflector for the new observatory near Jena of the German Academy of Sciences. It is convertible into a 53-inch Schmidt telescope.



Right: An American radio astronomer, W. C. Erickson of Convair Scientific Research Laboratory tells a commission meeting about the distribution of neutral hydrogen gas in our galaxy.



The Sternberg Astronomical Institute is the observatory of Moscow University (right far background). Its work includes radio time service, variable star researches, solar observations, and celestial mechanics.

half. The strongest evidence for this comes from the work of Dutch and Australian radio astronomers, as told in Dr. Struve's article.

The IAU subcommission charged with selecting a better pole was empowered, by vote of the general assembly, to decide on a final adopted position before the end of the year. Moreover, in the future galactic longitude will be counted from the direction to the galactic center, instead of from the intersection of the celestial and galactic equators, in Aquila. January 1, 1960, seems to be a desirable date for placing the new system in operation.

Cepheid Discussion. Our principal tool for plumbing the depths of space continues to be the Cepheid variable stars. Until a few years ago, the intrinsic brightness of a Cepheid variable was thought to be uniquely fixed by the period of its light variation. Now, however, it appears that each variety of Cepheid has a slightly different period-luminosity relationship. Doubt has also been expressed that the Cepheids in our Milky Way system, the Magellanic Clouds, and other galaxies are all of the same breed. The joint discussion organized by S. C. B. Gascoigne (Australia) and presided over by P. P. Parenago (U. S. S. R.) was intended to bring us closer to a solution of these problems. While many new and important facts were brought out, it can hardly be said that we have arrived at any firmer conclusions.

Mrs. C. Payne-Gaposchkin (U. S. A.) described the shapes and varieties of light curves for more than 600 Cepheids in the Magellanic Clouds observed over the past 35 years by H. Shapley and his associates at Harvard. Her paper and the following ones by Dr. Gascoigne and H. C. Arp (U. S. A.) showed that although many similarities exist between galactic and Magellanic Cloud Cepheids, there are important differences. One of the most striking of these is the overabundance (first recognized by Dr. Shapley) of rather short-period Cepheids in the Small Magellanic Cloud compared with the Large Cloud and our Milky Way system.

Similarity between galactic and Magellanic Cloud Cepheids was stressed by M. W. Feast and A. D. Thackeray (both of South Africa) on the basis of observations of spectra. On the other hand, G. E. Kron (U. S. A.) finds indications that the Milky Way Cepheids are intrinsically redder than those in the Small Cloud, but there was far from universal agreement on this point. More observations of high quality are needed.

The intrinsic luminosities of Cepheids were also discussed at length, but again the issues were not settled firmly. H. F. Weaver (U. S. A.) pointed out that many of the past discrepancies in determining the absolute magnitudes of Cepheids can be traced back to different assumptions as to the normal colors of these stars in our galaxy. For example, suppose we were to assume that the Cepheids are intrinsically quite blue, bluer than they actually are. Then the observed rather red color would suggest much space reddening, hence more obscuring interstellar dust between each variable and us than actually exists. We would be systematically underestimating the distance of such Cepheids from the sun, and an erroneous galactic distance scale would result.

The discussion at Moscow underlined the need for new observational data on the absolute magnitudes and colors of Cepheid variables. A recent breakthrough is the realization that numbers of Cephe-

Seen at a commission meeting, in the second row are, left to right, Geoffrey and Margaret Burbidge (U. S. A.), the writer of this article, and O. A. Melnikov (U. S. S. R.). Behind the last two sit J. H. Oort (Holland) and, right, J. L. Greenstein (U. S. A.).

The retired director of Leiden Observatory, Ejnar Hertzsprung (left), has contributed more to stellar astronomy than any other astronomer now living. Besides making the first H-R diagram and theoretical studies of fundamental importance, he greatly improved observational methods for variable and double stars.

ids are members of galactic star clusters. Since the distance of a cluster can be determined with high precision, we can obtain excellent estimates of the luminosity and intrinsic color of any Cepheid it contains. J. B. Irwin (U. S. A.) lists 11 Cepheids now known in galactic clusters, and work on their magnitudes and colors has begun.

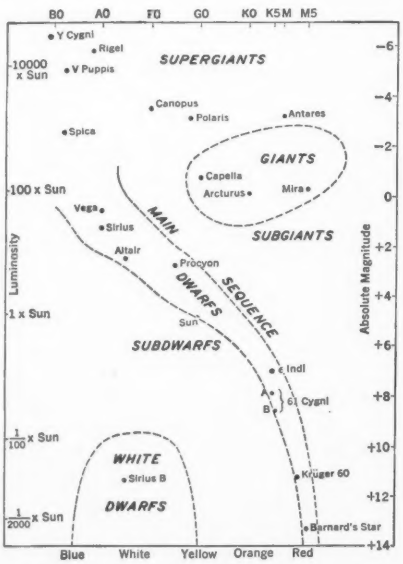
Two important contributions by Soviet astronomers included J. P. Pskovsky's review of the zero point of the period-luminosity relation, and E. D. Pavlovskaya's progress report on her measurements of the proper motions of cluster-type variables. The proper motions are derived by comparing star positions on recent photographs taken with the Sternberg Institute's 15-inch refractor with positions from old astrographic plates. There is general agreement that the cluster-type variables with periods a little under one day have absolute magnitudes averaging about +0.5 in blue light.

Magellanic Cloud Subcommission. There has long been a need for a group within the IAU to co-ordinate research on the Magellanic Clouds. Such a subcommission was established at Moscow under the direction of Dr. Gascoigne; it is part of Commission 28 (external galaxies). The group's tasks include preparing charts of the Clouds for observers, setting up standard sequences of star magnitudes and colors in the Clouds, and aiding the exchange of information among workers in this field.

Hertzsprung-Russell Diagram. Organized by J. L. Greenstein (U. S. A.) and E. Schatzman (France), the symposium on the H-R diagram covered a vast amount of material in its 20 papers. The first session, presided over by J. H. Oort (Holland), dealt with observations; the second, under V. A. Ambarzumian (U. S. S. R.), with theoretical problems. Unfortunately, H. N. Russell had died in February, 1957, but E. Hertzsprung (Denmark) was present in the full flower of his 83 years.

The H-R diagram is a plot of stellar spectral class (or color) versus absolute magnitude. During the half century this diagram has been used, its features, such as the main sequence, the giant branch, and the white dwarfs, have become part of everyday astronomical speech. More recently, we have come to look upon the H-R diagram as our chief way to exhibit the evolutionary tracks of stars of all kinds.

From precise studies of the spectra of stars, and from brightness measurements in different colors, much can be learned about the chemical composition of stellar atmospheres, which vary in a fairly well-determined manner with a star's age. G. and M. Burbidge (U. S. A.) gave a fine summary of the abundances of the elements in different types of stars. Those formed early in the history of our galactic system are found to be poorer in the elements heavier than hydrogen than are stars formed more recently. This aging effect is shown in extreme form by stars in globular clusters (presumably very ancient, five or more billion years old), as indicated by some of Dr. Greenstein's spectra.



This simplified H-R diagram shows the positions of many well-known stars in relation to the main sequence and other important named areas of the diagram. Adapted from "Astronomy," by Skilling and Richardson.

Hitherto relatively unpopulated areas of the H-R diagram are beginning to be filled in. In the lower left corner (domain of the hot, faint stars), Dr. Greenstein recognizes several subdivisions. The white dwarfs are there in the company of old novae, SS Cygni variables, blue-white stars in globular clusters and the galactic halo, and hot subdwarfs. The relations among these groups are not clear, but here truly is the celestial junkyard for worn-out stars.

During the initial stages of stellar evolution, stars develop by gravitational contraction. The T Tauri variables, young stars often found at the edges of dark nebulae, fill a wide band in the H-R diagram, between the giant branch and the main sequence, according to I. M. Kopylov (U. S. S. R.). These stars evolve along tracks of more-or-less constant absolute magnitude until they reach the main sequence, where nuclear transformations start in earnest.

With the development of theoretical interpretations of the H-R diagram, it is fortunate that new and more precise methods of placing particular stars in the diagram are becoming available. D. Chalonge (France) and his associates presented new results based on the French three-dimensional system of spectral classification, which permits a direct sorting of the stars by ages. Bengt Strömgren (U. S. A.) and coworkers are making excellent progress with multicolor observations, whereby even very faint stars are classified by photoelectric measurements at selected narrow intervals of wave length. Nancy Roman (U. S. A.) reported her success in finding subdwarf stars in the galactic halo by means of their excess brightness in ultraviolet light.

Briefly Noted. Some other scientific reports and happenings of particular interest to Milky Way researchers deserve mention. Perhaps most impressive are successes with image-converter tubes, the electronic devices that promise to revolutionize astronomical photography. Many of us saw for the first time the excellent results obtained in France with equipment built by A. Lallemand.

C. Fehrenbach and M. Duflot (France) told more about their measurements of

the radial velocities of stars, using an objective prism instead of the traditional slit spectrograph. Their second list contains radial velocities for 310 stars, with errors less than ±5 kilometers per second for the majority. Their equipment can reach stars as faint as 10th magnitude. This technique will be applied shortly to stars in the Magellanic Clouds.

The Czechoslovak astronomer J. Alter presented the commission on star clusters with a copy of his new general catalogue of clusters. In card form, it promises to have many uses in the years to come.

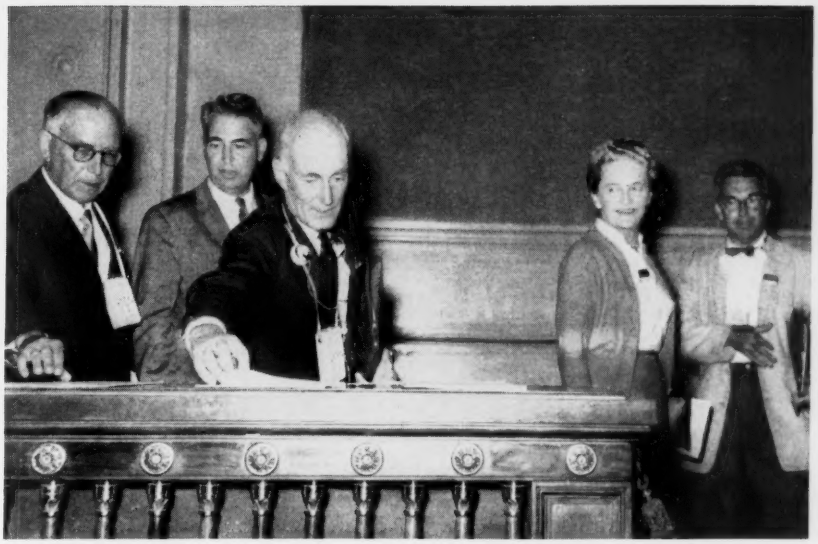
The commission on photometry made plans to issue during the next three years a general catalogue of magnitudes and colors of stars in both the northern and southern skies.

Astronomers continue to feel the need for a general catalogue of diffuse nebulae. A. W. Rodgers and his colleagues in Australia were urged by Commission 34 to proceed promptly with the preparation of an atlas and catalogue for the southern hemisphere, to be made from photographs taken with an 8-inch f/1 Meinel-Pearson Schmidt camera.

Several limited international symposia are being planned for the next few years. One on planetary nebulae and another on star clusters will almost certainly take place. There was discussion of a third, on galactic dynamics and the Magellanic Clouds. Other symposia planned are on site selection and on the aerodynamical problems of stellar atmospheres.

Some IAU Business. The big event at the concluding general assembly is always the selection of the new president and general secretary of the IAU. A. Danjon of Paris, who had been an excellent president, was succeeded by Dr. Oort of Leiden, a very popular choice.

P. T. Oosterhoff, also of Leiden, general secretary for the past six years, is being succeeded by D. H. Sadler of the British Nautical Almanac Office. New vice-presidents of the IAU are L. Goldberg (U. S. A.), R. M. Petrie (Canada), B. Sternberk (Czechoslovakia), and R. H. Stoy (South Africa).



Holland's J. H. Oort (center), president elect of the IAU, reaches for some abstracts of symposium papers at the Moscow meeting. A former president is at the left, Bertil Lindblad (Sweden), while between them is Nicholas U. Mayall of Lick Observatory. Waiting for them at the right are Mrs. Mayall and Carl K. Seyfert, Dyer Observatory.

Among the new appointments of American astronomers to commission chairmanships are: F. P. Scott, positional astronomy; Dr. Goldberg, solar radiation; P. van de Kamp, proper motions and parallaxes of stars; N. U. Mayall, galaxies; L. Spitzer, Jr., diffuse nebulae; M. Schwarzschild, internal constitution of the stars; and others.

The four old commissions on solar problems were combined into two: No. 10, solar activity; and No. 12, solar radiation and the structure of the sun's atmosphere. Similarly, Commissions 29 and 36 were merged into a single Commission 29, for problems of stellar spectra. A new Commission 43 was established for magnetohydrodynamics and the physics of ionized gases.

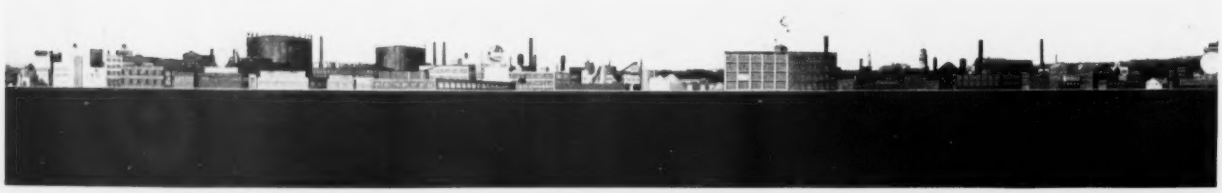
The Moscow meetings were preceded and followed by excursions to the far-flung observatories of the U. S. S. R. I visited the Poulkovo Observatory in Leningrad before the congress began and the Crimean observatories afterward. Other astronomers went on trips to Georgia and Armenia, and quite a few left the Soviet Union via Leningrad, Odessa, or Tashkent.

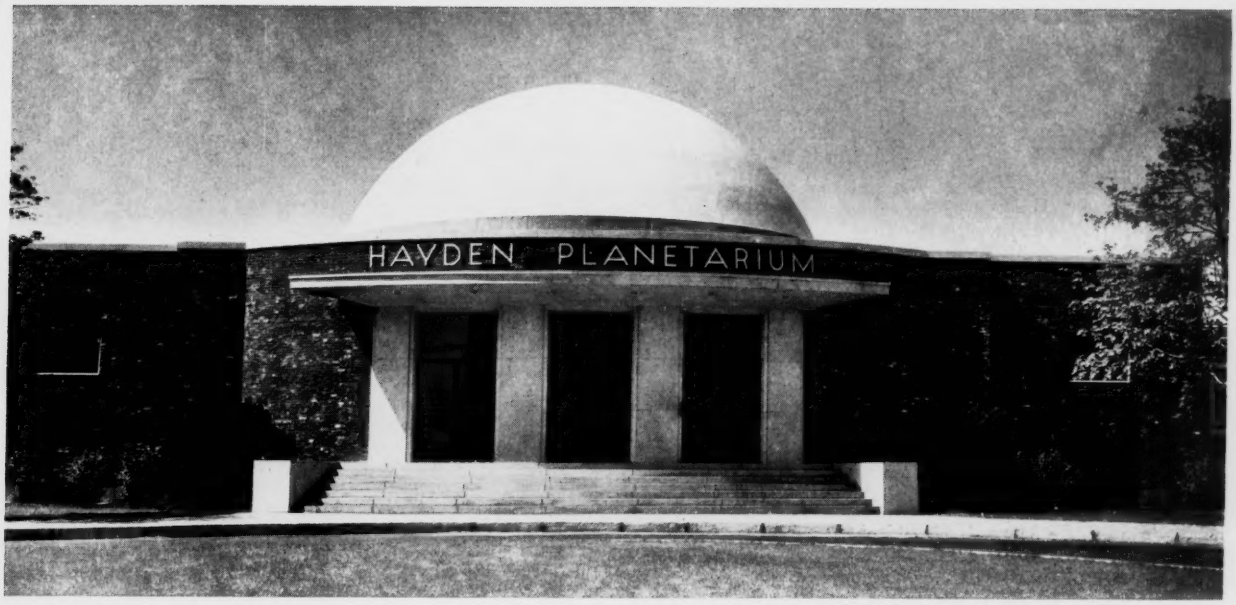
The U. S. S. R. seems destined to advance rapidly in astronomy. All of us return home deeply impressed by what the Soviet astronomers are doing to equip and staff their observatories. It is good, also, to have an opportunity here to acknowledge the fine hospitality of our Russian colleagues before, during, and after the Moscow meetings.

The 1961 assembly of the IAU will be held in the United States. Washington, D. C., Pasadena and Berkeley in California are among the possible meeting sites, but no decision among them has been made. The 1964 congress will probably be held in western Europe, with West Germany a likely place. Plans for 1967 and 1970 are still vague, but I had the honor of transmitting an Australian invitation for a meeting to be held at Sydney or Canberra.

The Poulkovo Observatory is situated on a hilltop 12 miles south of Leningrad, where these modern buildings were dedicated in May, 1954, as the famous institution had been destroyed during World War II. Several of the domes in this photograph by J. J. Nassau are part of separate observatory buildings.

Director John Patterson demonstrates the Charles Hayden Planetarium's new projector to a special audience. The parts of the Korkosz instrument may be compared with the key drawing on the facing page. The moving-planet projectors will be housed in the smooth ring spaces, between the quarter spheres (for faint stars) and the hemispheres (for bright stars). In the center of the instrument, the angle of $23\frac{1}{2}$ degrees between the equator and ecliptic is plainly seen. The stars in this composite picture have been added by an artist. The photograph below, of a portion of the chamber's three-dimensional skyline, shows buildings on the Cambridge side of the Charles River basin.





The entrance to the Charles Hayden Planetarium, part of the Museum of Science, which is situated on land made available by the Metropolitan District Commission on the dam at the foot of the Charles River basin. The parts of the Korkosz projector are shown in the drawing below by Russell Lenz, of the "Christian Science Monitor." All photographs in this article are courtesy of the Museum of Science.

Boston's Planetarium Opens

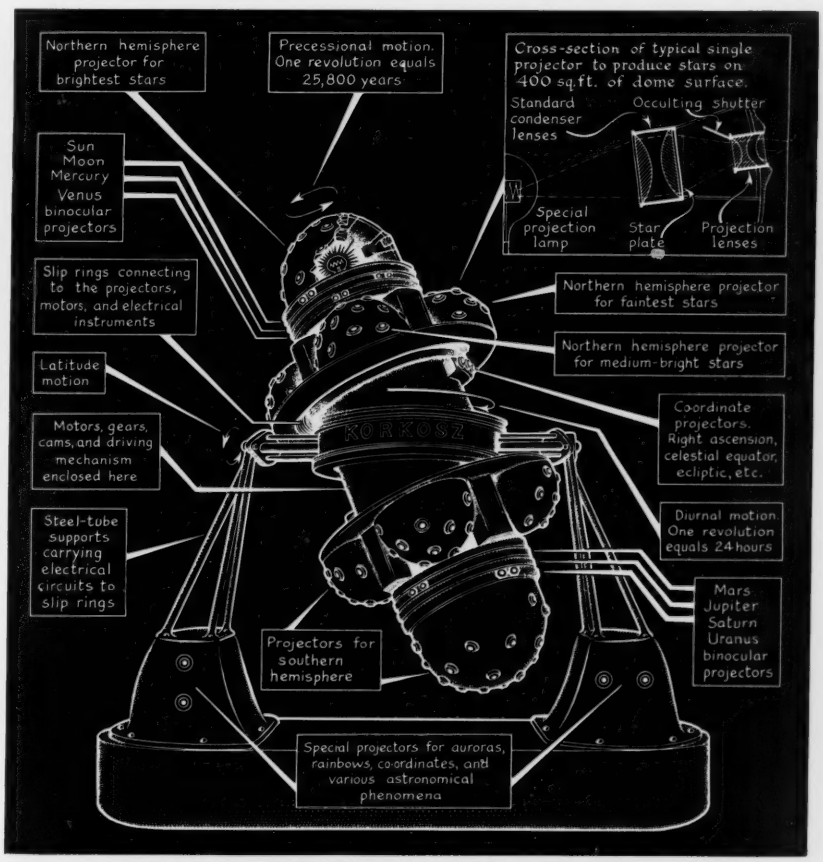
JOHN PATTERSON, *Charles Hayden Planetarium, Museum of Science*

MODERN planetariums are highly specialized theaters equipped with many ingenious instruments to create an illusion of the universe. Almost everything observable above the earth's surface is included, from meteorological phenomena of our atmosphere, through the motions of the planets and satellites of the solar system, to distant galaxies.

It is now more than seven years since *Sky and Telescope* readers first learned of our plans (May, 1951, issue, page 159) to build a major planetarium as part of Boston's Museum of Science, which is itself still in the process of development and construction. On March 13, 1951, the east wing of the museum was opened to the public; the planetarium was opened on October 21st of this year; the central building is being constructed as funds become available.

The opening of the planetarium climaxes many years of effort by Bradford Washburn, the museum's director, John and Frank Korkosz, inventors and builders of the projector, and a host of technicians, builders, and artists. We believe that in many respects the new Hayden Planetarium of Boston is the world's finest installation of its kind, even though we have opened it without the planet projectors. These are in final assembly at Springfield, Massachusetts.

As the sketch on page 15 shows, the building has every needed facility. The


Northern hemisphere projector for brightest stars
Precessional motion. One revolution equals 25,800 years
Cross-section of typical single projector to produce stars on 400 sq.ft. of dome surface.
Standard condenser lenses
Occulting shutter
Special projection lamp
Star plate
Projection lenses
Sun
Moon
Mercury
Venus
binocular projectors
Slip rings connecting to the projectors, motors, and electrical instruments
Northern hemisphere projector for faintest stars
Northern hemisphere projector for medium-bright stars
Latitude motion
Coordinate projectors. Right ascension, celestial equator, ecliptic, etc.
KORKOSZ
Motors, gears, cams, and driving mechanism enclosed here
Steel-tube supports carrying electrical circuits to slip rings
Diurnal motion. One revolution equals 24 hours
Mars
Jupiter
Saturn
Uranus
binocular projectors
Projectors for southern hemisphere
Special projectors for auroras, rainbows, co-ordinates, and various astronomical phenomena

Above: Parts of the skyline depicting Massachusetts General Hospital are being installed by Gordon Mills.

Left: Frank Korkosz holds one of the Milky Way projectors. This unit employs a bright lamp and a two-mirror optical system to achieve the equivalent of pinpoint projection.

interior projection chamber is 60 feet in diameter and 38½ feet high. The seats are placed well within the periphery, so that no spectator is cut off from a view of the sky immediately behind him, and no one is seated under the lip of the chamber where he would lose the illusion of being under the starry vault of the heavens. Nevertheless, our seating capacity is 276, the maximum allowed us by the city's fire regulations. The seats have been specially designed to provide a restful observing position for each spectator.

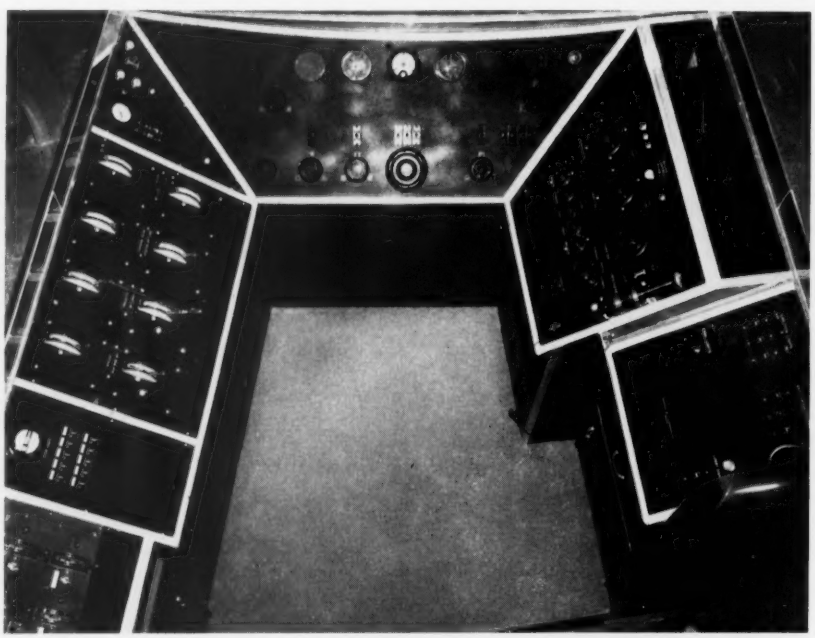
The dome is made of perforated aluminum having 15 holes per square inch, more than 12 million holes for the entire area. The dome horizon is 8½ feet above the floor, but it is not cut out or silhouetted in any way. At the press of a switch, the lecturer can employ a hydraulic system to raise into view a colored three-dimensional reproduction of the Boston-Cambridge skyline as seen from the museum, which is located at the foot of the Charles River basin. The panorama is complete with electric signs, John Hancock building weather signal, and electric clock. This skyline can remain in position during an entire lecture, or it may be lowered out of the way, to be replaced by other horizon effects produced by special projectors.

If the room is in darkness as the visitor enters the chamber, he can find a seat with the aid of a subdued red glow on the carpeted floor. The cardinal points of the compass are illuminated, as in other planetariums, and north and south can be reversed when a trip across the earth's poles is demonstrated. If a stop is made at the north pole, all the direction markers indicate south, since the observer is as far north as he can go.

Before the lecture begins, the audience sees the three-ton blue-and-silver projector in the center of the room — perhaps the only large planetarium projector that is not black! The instrument itself is protected by a metal rail, and within the enclosure are concealed some of the special-effects projectors. Together with those in the central portions of the instrument itself, they produce the ecliptic, celestial equator, meridian, north and south celestial poles, and mark out the precessional cycle. Also reproducible are a lunar eclipse, the rainbow, lightning, meteor showers, and the artificial satellites Sputnik I and Vanguard I.

In the new Hayden Planetarium, the demonstrator does not have to pass into the aisle of the audience chamber to get to the lecturing console. From his office he can go through a passageway to the technician's room, and then directly into the console. The latter incorporates all the controls, more than in any other planetarium, for the projector, special effects, lighting, and the sound system, the lecturer being independent of the technician for any of the effects that he may wish to use. About 8½ miles of connecting wires run from the desk to other parts of the chamber.

The left-hand panel of the console has



The convenient arrangement of the console is indicated in this view looking down from the skyline behind it. The dimmers at the left regulate the permanent and special lighting effects, planetarium projector controls are at the front, and sound and lights at the right.

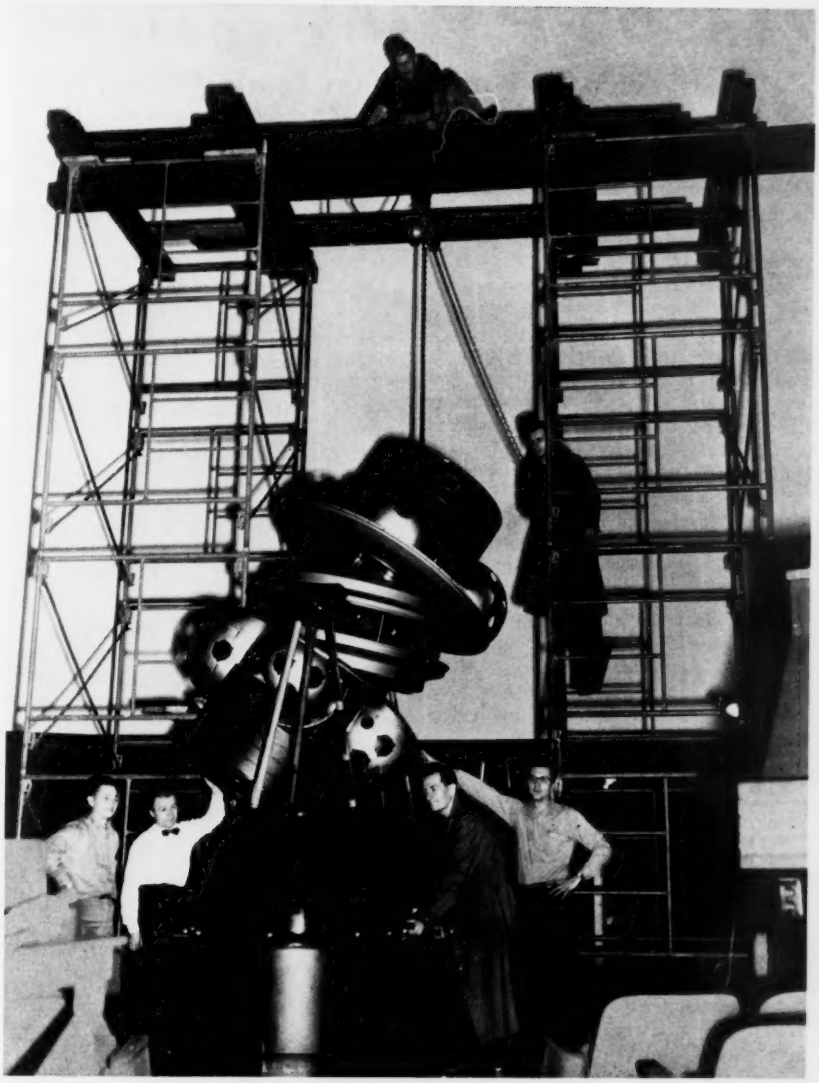
the special-effect switches and dimmers, the permanent lighting effects, and the hydraulic skyline controls. The front panel controls the projector itself, and has a latitude dial, time and date indicators that show the setting of the instrument, and an automatic clock. The latter operates a master switch turning off the entire electrical system, to prevent the instrument from running all night if someone forgets to turn it off. The right-hand panel controls the operational lights, cardinal points, entrance, and so forth, as well as the sound system.

Directional sound is provided by 32 speakers placed so that the apparent source can be made to go completely around the horizon or from one side of the chamber to the other through the zenith. Sound effects include passing trains, jet planes, jungle noises, thunder, and city traffic.

The labels of the control console are lighted dimly from behind – an aid to the lecturer. There are emergency battery-operated lights and a telephone within the lecturer's reach. One innovation is an elapsed-time counter which records the length of time the many lamps in the projection instrument are turned on and tells when to replace them.

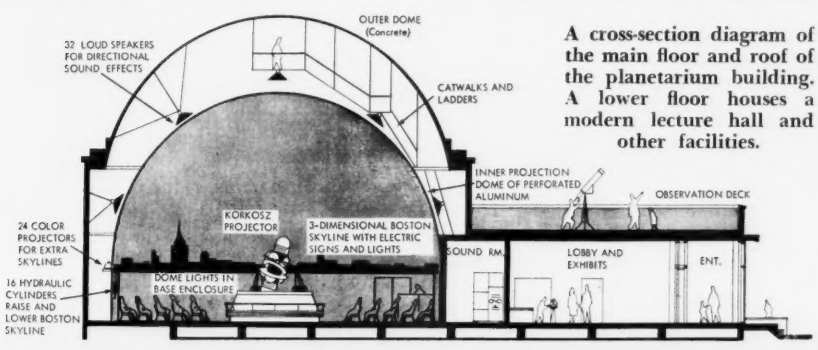
The Korkosz projector is unique, being the first of its kind. It produces a more realistic sky because light sources of different brilliance are used for bright, medium, and faint naked-eye stars. This has required a change in over-all design from the dumbbell shape of conventional projectors. In each of the hemispheres at the ends of the instrument is a 1,000-watt bulb, used for the 88 brightest stars in the sky, each one with its own optical system. In the quarter spheres there are 500-watt bulbs for 3rd- and 4th-magnitude stars, and 250-watt ones for 5th and 6th magnitudes, more than 9,600 stars being projected in all.

The Korkosz instrument incorporates all the refinements necessary in a modern planetarium projector. It provides for the motions of the planets, backward as well as forward in time, for change of the observer's latitude, for the 25,800-year cycle of precession, for the phases of the moon, and more. In designing it, standard motors and components have been used wherever possible.



A scaffold had to be erected in order to install the instrument. The author is at the top, and halfway up on the right is John Janek. Standing, left to right, are William and John Korkosz, Allen Thompson, and Stanley Korkosz. American Planetarium Corp. photograph.

Our initial schedule calls for 20 shows each week, with each lecture lasting about 50 minutes. The times on Tuesday, Wednesday, and Thursday are 9:45 a.m., 11:00 a.m., and 3:00 p.m. On Friday we add shows at 5:30 and at 8:00 p.m. The Saturday schedule is 11:00 a.m., 2:00 and 3:30 p.m., while on Sunday the times are 1:30, 2:45, and 4:00 in the afternoon. The 9:45 a.m. weekday lectures, for school groups only, will be by Valerie Roberts, who will integrate her talks into local school curricula. The lecturing staff consists of Walter N. Webb, Jackson F. Wilcox, and the writer. Our technicians are Charles S. Oates and Mr. Wilcox.


OUTER DOME (Concrete)
32 LOUD SPEAKERS FOR DIRECTIONAL SOUND EFFECTS
CATWALKS AND LADDERS
INNER PROJECTION DOME OF PERFORATED ALUMINUM
OBSERVATION DECK
KORKOSZ PROJECTOR
3-DIMENSIONAL BOSTON SKYLINE WITH ELECTRIC SIGNS AND LIGHTS
24 COLOR PROJECTORS FOR EXTRA SKYLINES
DOME LIGHTS IN BASE ENCLOSURE
16 HYDRAULIC CYLINDERS RAISE AND LOWER BOSTON SKYLINE
SOUND RM.
LOBBY AND EXHIBITS
ENT.

A cross-section diagram of the main floor and roof of the planetarium building. A lower floor houses a modern lecture hall and other facilities.

Admission to the planetarium and museum together is one dollar for adults and 50 cents for children – half price for museum members.

New England's first major planetarium opens with great expectations of increasing interest and awareness of astronomy on the part of the general public. From the gigantic Chesley Bonestell mural of a panorama on the moon (August, 1957, *Sky and Telescope*), to the brilliant and nearly perfect rendition of nature's sky in the planetarium chamber, man's increasing knowledge of the universe will be presented for all to understand.

Amateur Astronomers

FT. WAYNE, INDIANA

With the support of the local press, radio and television stations, the Ft. Wayne Astronomical Society has made impressive progress since its formation last March (page 349, May issue). It now has 99 members, including 31 juniors. Meetings for the coming year will be held at the Elks Country Club on the third Wednesday of each month, and there will be one or more star parties.

There is an active telescope making group, with 42 telescopes now under construction. Two courses in basic astronomy are being planned — one being offered through the local branch of the Indiana University extension division, and the other being taught by Blanche Nielsen, a science teacher at Ft. Wayne Central high school.

Last July 11th, the society held a public exhibit in Shoaff Park, in co-operation with the park commission, attended by some 500 spectators. On display were a Minitrack station, telescopes, mirror grinding equipment, some astronomical movies, and rocket and satellite models. On July 23rd, about 350 persons viewed Jupiter and Saturn at a star party.

The society's officers are Herbert Krueger, president; Bert Leifer, vice-president; Harry McLain, treasurer; and Mrs. Margaret Wininger, R. R. 3, Hillegas Rd., Ft. Wayne, Ind., secretary.

FT. DODGE, IOWA

A group of 24 amateurs, half of whom are juniors, organized the Ft. Dodge Astronomy Club about eight months ago. Meetings are on the first and third Fridays of the month at 7:30 p.m. in the First Methodist Episcopal Church. The president is William W. Van Gundy, 1210 First Ave. N., Ft. Dodge, Iowa.

JUNIORS IN JAPAN

Created three years ago, the Japan Astronomy Club has 30 members throughout our country. The youngest member is 15 and the oldest is 22 years old. Since we cannot meet together, we communicate with each other by means of letters.

Each of us possesses a telescope, ranging from a 2-inch refractor to a 6-inch reflector. Our club publication is called the *Tentai*, which means "celestial body."

We would like to correspond with junior societies in the United States.

TAIZO MUTA
96-4 Kyomachi-3-chome, Kurume-shi
Fukuoka-ken, Japan

LAS VEGAS, NEVADA

A group of 21 adults and 13 juniors have formed the Astronomical Society of Southern Nevada. Further information may be had from the secretary, Tom Constanten, 1650 Michael Way, Las Vegas, Nev.

TROY AMATEURS REORGANIZE

After a year of inactivity, the Troy Astronomy Club was reorganized last August and now has 17 members. Monthly meetings are held on the first Saturday on the campus of Rensselaer Polytechnic Institute; an advanced group meets each Saturday at the R.P.I. Observatory.

We have the use of more than 13 telescopes, including the school's 12-inch reflector. Several members are now building a grinding machine that will hold mirrors up to 25 inches in diameter and can be adapted to 30 inches. We also publish a monthly bulletin of society news and astronomical data.

Interested amateurs in our area are invited to contact me.

DAVID HARRIS
1032 19th St.
Watervliet, N. Y.

BRISTOL, PENNSYLVANIA

Six amateurs have founded the Polaris Astronomical Society. The secretary is Alma K. Kovach, 3524 Carnarvon Ave., Bristol, Pa.

NEW YORK JUNIORS

The Junior Astronomy Club recently moved its headquarters from the Brooklyn Public Library to the Washington Square campus of New York University in Manhattan. The society has a membership of 400.

As part of its 30th anniversary celebration, the club is presenting a special lecture series, in addition to its regular monthly program, on "The Theory and Practice of Astronomical Observing." The speakers will be amateurs who have achieved prominence in such fields as meteors, variable stars, comets, and aurorae.

Newly elected officers are Joel S. Levine, president; Ian Fries, vice-president; Paulette Fote, secretary; and Leonard Richardson, treasurer. Arthur Pearlmutter is advisor. Inquiries about the group should be sent to Junior Astronomy Club, 100 Washington Square East, New York 3, N. Y.

KNOXVILLE, TENNESSEE

A group of eight adults and 23 juniors has formed the Knoxville Astronomical Association. Interested persons should contact David L. Bower, 2110 Fairmont Blvd., Knoxville 17, Tenn.

CLINTON, WISCONSIN

Active for the past year and a half, the Clinton Junior Astronomers has 11 members from 10 to 14 years of age. Meetings are held on the first and third Thursdays each month, at 7:30 p.m. in the clubroom at 244 Allen St. Roger A. Hamilton is the group's adult leader.

THIS MONTH'S MEETINGS

Cambridge, Mass.: Bond Astronomical Club, 8 p.m., Harvard Observatory. November 6, Leon Campbell, Jr., Smithsonian Astrophysical Observatory, "The First Year of Moonwatch."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. November 14, Dr. Geoffrey Keller, National Science Foundation, "The New National Observatories."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Health Museum Planetarium. November 24, R. T. Harvey, "Astronomy of Eratosthenes."

Edinburg, Tex.: Magic Valley Astronomical Society, 8 p.m., Pan American College science building. November 14, Paul R. Engle, Pan American College, "Lunar Missile Impact Survey."

Madison, Wisc.: Madison Astronomical Society, 8 p.m., Washburn Observatory. November 12, meteorologist from Truax Field weather station, "Weather, Radar, and the Stars."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. November 5, Dr. R. M. Emberson, Associated Universities, Inc., "The National Radio Astronomy Observatory."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. November 21, Dr. Martin Schwarzschild, Princeton University Observatory, "Astronomical Photography at High Altitudes."

Plainfield, N. J.: Amateur Astronomical Society of Bergen County, 6:30 p.m., Park Hotel. November 14, Charles A. Federer, Jr., Harvard Observatory, "Some Western Observatories."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. November 1, Leonard Batz, AC Spark Plug Division, "Gyroscopes and Earth Motion."

STAMFORD, CONNECTICUT

The Fairfield County Astronomical Society has formed a special division to meet the needs of younger people and others who wish to have proper preparation for the society's regular program. This group will meet on the second Monday of each month at 8 p.m. in the Stamford Museum.

UPPER MONTCLAIR, NEW JERSEY

Nine amateurs have set up the Montclair Telescope Club. Membership is limited to those actively interested in astronomy and who own, or plan to obtain or build, a telescope.

One member, Maxwell Kimball, an architect, has built a 5-inch refractor, and Richard Boegehold has constructed an 8-inch Newtonian. The club plans to set up a mirror grinding machine. Further information may be obtained from Mr. Boegehold, 280 N. Mountain Ave., Upper Montclair, N. J.

The Chemical Composition and Ages of Stars

OTTO STRUVE, *Leuschner Observatory, University of California*

ON MAY 27, 1958, Bengt Strömgren, now a member of the Princeton Institute for Advanced Studies and previously director of Yerkes and McDonald Observatories, delivered the Halley Lecture for 1958 at Oxford University. To an audience of British astronomers, he summarized investigations by himself and his colleagues in the field of photoelectric narrow-band photometry and its applications to problems of the composition of stars and their ages.

In the introduction to his discourse, Strömgren called attention to a fact emphasized in the 1933 Halley Lecture by H. N. Russell, who said: ". . . stellar spectra are remarkably similar *inter se*. The variety is much less than it would be if the relative abundances of many elements varied appreciably from star to star."

Hence, argued Strömgren, "the observed uniformity suggests that the problems of the interpretation of stellar spectra may be tackled successfully, in a first approximation, on the assumption of uniform chemical composition of the stars. As the analysis progresses, deviations from this simple picture, if they exist, will become apparent."

In recent years astronomers have found it convenient to describe the evolution of a star with a given mass in terms of an "evolutionary track" in the Hertzsprung-Russell diagram. One example of such a track is pictured here (Fig. 1). For stars of larger masses, the tracks lie higher in the diagram, and the shapes of the curves are not quite the same. But for stars in general we can distinguish four principal sections of the track.

First comes the stage of gravitational contraction, which carries the newly condensed star from right to left in the H-R diagram, and lasts only a relatively short time. Second, during the long-lasting main-sequence stage, the amount of energy generated by thermonuclear processes in the deep interior of the star is balanced by the energy radiated from the stellar surface into space. Third, as the hydrogen available for fuel becomes exhausted, the balance between energy produced and energy radiated is no longer maintained, and the star changes its characteristics fairly rapidly from those of the main sequence to those of the upper right corner of the diagram. Fourth, there is the final stage of very high central temperature, during which the star evolves more or less rapidly from right to left, crossing the main sequence, and ultimately becoming a white dwarf.

If two stars were to have different initial chemical compositions, say one was mainly hydrogen, the other mainly helium, the same four sections would occur, but their tracks would not coincide even for stars of the same mass. But, on Strömgren's assumption that stars have approximately the same initial composition, different evolutionary tracks represent differing stellar masses. In other words, the location of each track would depend solely on the mass of the star.

Then, if it were true that the tracks of stars of differing mass do not intersect, the precise location of the star on the H-R diagram would give us at once the mass of the star and its age. In general, we cannot make this assumption, for the tracks probably do intersect, even if the initial compositions are precisely the same, but with some simplifications, an assumption of nonintersection is likely to be valid.

First, suppose we can distinguish between stars in the early contracting stage and those in the much later hydrogen-exhaustion stage. Further, consider only stars, within a fairly narrow range of mass, that have not departed very greatly from the main sequence.

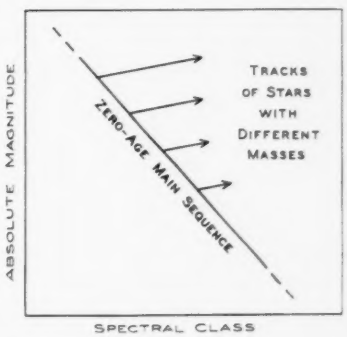


Fig. 2. The more massive a star, the higher in the H-R diagram is its track on leaving the main sequence, and the more rapid is its evolution.

We will now consider the *B*-type stars, the hot, blue ones at the upper end of the main sequence. For these, the early contracting stage may be disregarded because it requires only a short time. We assign arbitrarily an age of zero to those *B* stars that are just beginning their main-sequence stage, and we follow the third evolutionary stages of stars of different masses, moving rightward from the main sequence, as in Fig. 2. These tracks do not intersect. Hence, to determine age and mass (if the latter is not already directly known from observation), all we need is to specify the exact location of the star in the H-R diagram. That is, we need only determine the star's absolute magnitude and spectral type, or their equivalents.

But conventional spectrographic methods have been of limited precision, and Strömgren has developed a more accurate way to classify spectra two-dimensionally. It is used to improve the classification after a good spectral type and absolute magnitude (or luminosity class) have been secured by the Morgan-Keenan or the Chalonge spectrographic procedures.

In the near-ultraviolet spectrum of early-type stars, there is a conspicuous drop in the brightness of the continuous

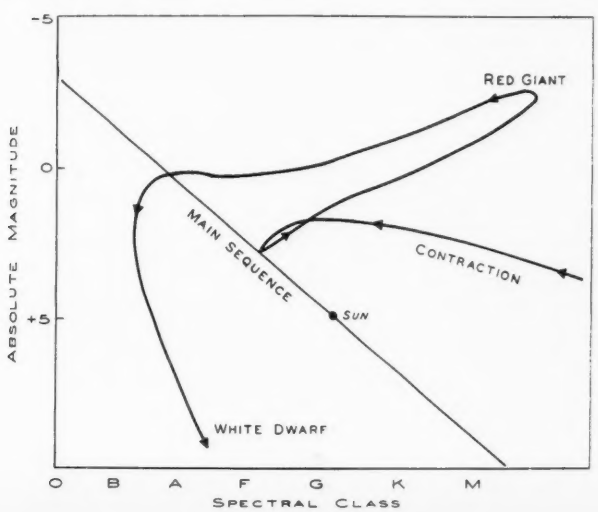


Fig. 1. Arrows trace the evolution of a star that contracts to reach the main sequence at spectral type F, where its thermonuclear processes begin in earnest. (See page 584, September issue, for another recent representation.)

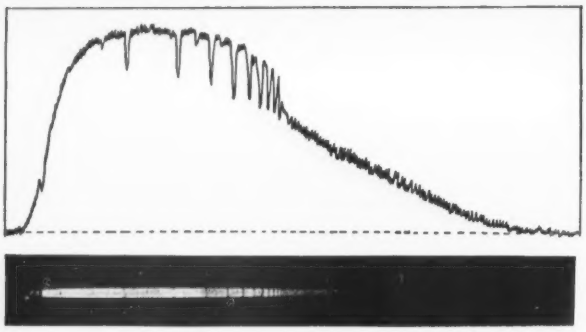


Fig. 3. This intensity tracing was made from the spectrogram that is shown below it, of a B3-type star. (Contrary to custom, the shorter wave lengths are toward the right.) The strongest lines are of hydrogen and helium; where they merge the continuous spectrum intensity falls off sharply—the Balmer discontinuity.

background as we pass from the long-wave-length to the short-wave-length side of the limit of the Balmer series of hydrogen lines. This drop is known as the *Balmer discontinuity* (Fig. 3). From the extensive spectrographic work by D. Barbier, by D. Chalonge and E. Vassy, and by Y. Ohman more than 20 years ago, we know that in *B*- and *A*-type stars (and to some extent also in *F* stars) the depth of the Balmer discontinuity is a very good indicator of the surface temperature.

Similarly, from the work of B. Lindblad, and more recently especially of R. M. Petrie, we know that the strength of the Balmer lines, for instance Hβ, depends mostly on stellar luminosity (Fig. 4), and only to a lesser degree upon the surface temperature. Hence, it should be possible to place any star in the H-R diagram for which the depth of the Balmer discontinuity and the strength of the Hβ line are known with high accuracy.

Strömgren's contribution is a method of measuring these two quantities with a photoelectric photometer. He makes six successive measurements, letting the star's light pass through each of six narrow-band filters:

Filter	*Peak Transmission* (angstroms)	*Band-width* (angstroms)
a	5000	90
b	4861 (Hβ)	35
c	4700	100
d	4500	80
e	4030	90
f	3600	350

The brightness of the star as observed through each filter can be called I_a, I_b, and so on, respectively. Then Strömgren computes two indices: l to describe the strength of the Hβ line, and c to describe the depth of the Balmer jump (Fig. 5):

$$l = 2.5\ (\tfrac{1}{2}\log I_a + \tfrac{1}{2}\log I_c - \log I_b),$$

$$c = 2.5\ (2\log I_e - \log I_d - \log I_f).$$

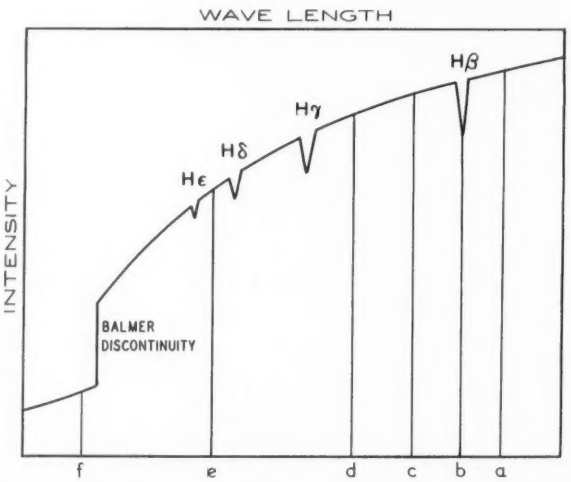


Fig. 5. In this schematic diagram of a stellar spectrum, a to f indicate the wave lengths at which B. Strömgren measures the brightness of the star. From them he deduces index numbers which describe the strength of the hydrogen-beta line and the depth of the Balmer discontinuity. These index numbers reveal the age and mass of the star.

The great advantage of these Strömgren index numbers is that they describe the star alone, being virtually unaffected by interstellar reddening. (The drawback to the conventional color index, photographic magnitude minus visual, is that it depends both on the intrinsic color of the star and the reddening effects of interstellar dust.) In the case of l, if the star is reddened, I_c will be depressed relative to I_a, but I_b will be depressed by an intermediate amount. The wave lengths of a and c were chosen nearly symmetrical with respect to b, to make the effects of space reddening cancel out in the formula for l. A similar argument holds for the other index, c.

Because of the extreme precision of photoelectric measurements, the probable error of one observation of l is only ± 0.004 magnitude, for $c \pm 0.008$ magnitude.

In order to study the ages and masses of the stars, it is not necessary to convert Strömgren's l and c indices into the conventional parameters, absolute magnitude and spectral class. He simply plots each star in a diagram such as Fig. 6, with l as the ordinate and c as the abscissa. To estimate the precision of his indices in terms of absolute magnitude and spectral class, Strömgren has calibrated l and c by means of W. W. Morgan's spectral types and a series of absolute magnitudes determined by A. Blaauw and by O. Eggen, D. K. Harris, and H. L. Johnson. The resulting probable error of one ob-

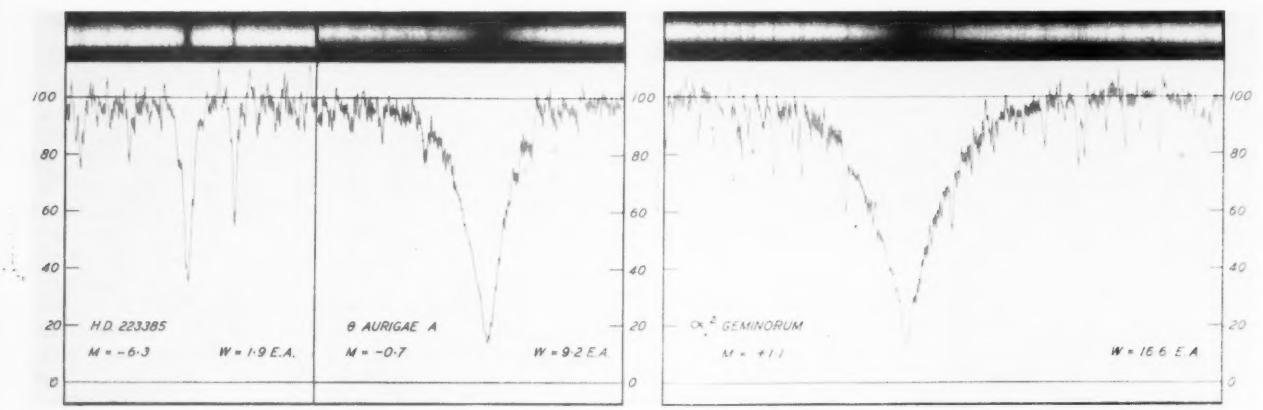


Fig. 4. The very strong dark line in each of these three stellar spectra is hydrogen gamma. Note how the width and depth of this line increase in passing, left to right, from the supergiant star HD 223385, to the giant star Theta Aurigae A, to the main-sequence object Castor. Dominion Astrophysical Observatory photograph.

servation by Strömgren is only 1/100 of a spectral class and ±0.02 to ±0.03 in absolute magnitude — very satisfactory precision indeed! The departure of a star from the main sequence in the *c-l* diagram is usually many times larger than these probable errors.

Let us examine Fig. 6, which contains stars of five luminosity classes, with supergiants (class I) at the top and marked by triangles. Some stars of the Pleiades cluster of early spectral type are included, marked by squares. The zero-age main sequence is represented by a line, derived independently from many measurements of the *l* and *c* indices of very young stars belonging to two stellar associations in Orion and Scorpius (I Orionis and II Scorpii). These stars are not plotted in the diagram.

We see that the supergiants of type *B* are easily distinguished from other *B*-type stars. Strömgren does not discuss their evolution. The other stars lie above the zero-age main sequence by different amounts, indicating differing evolutionary ages.

In Fig. 6, Strömgren has superimposed upon the star plot a network of curves computed from the theoretical work of R. J. Tayler and R. S. Kushwaha. The roughly horizontal bars are evolutionary tracks, while the longer, thin lines approximately parallel to the zero-age main sequence represent different ages. These curves apply to stars of spectral type *B*3 and later.

Strömgren has discussed, as one example, the brighter members of the Pleiades that fall in this part of the *c-l* diagram. From Fig. 6 we see that their ages lie between 50 and 75 million years (with one near 100 million), in good general agreement with other estimates of the age of this cluster: W. Lohmann's 100 million years and S. von Hoerner's 80 million.

Early in this article we discussed Strömgren's beginning assumption — that all *B* stars had the same initial chemical composition. To test this hypothesis, he compared his own measurements of *l* and *c* with the best available spectral types and absolute magnitudes for stars in the

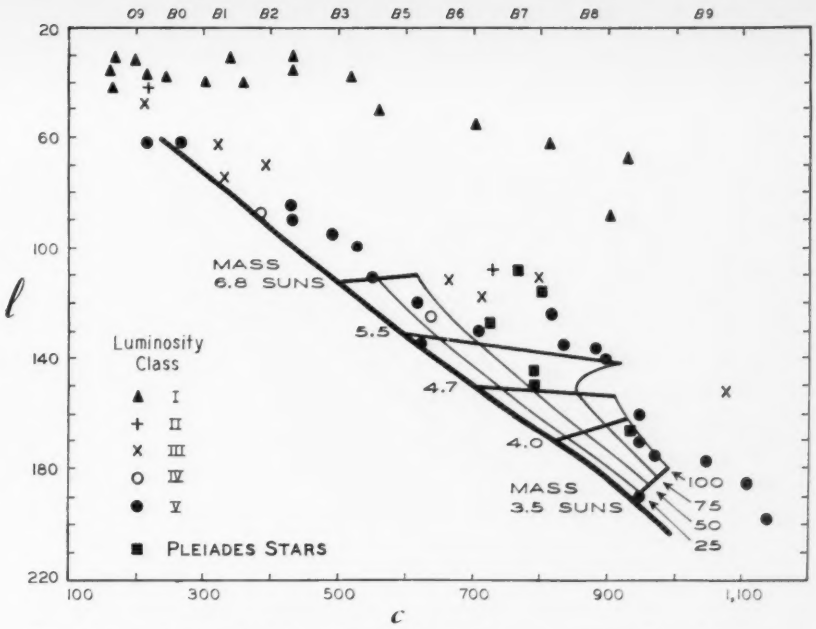


Fig. 6. Plotted points in this c-l diagram by Strömgren represent B- and A-type stars he has observed. The long, thin lines nearly parallel to the main sequence, which are labeled 25, 50, 75, and 100, are ages in millions of years since the stars left the main sequence. The luminosity class I refers to supergiants, III to giants, and V to dwarfs.

associations I Orionis and II Scorpii. If the initial compositions of these two associations had been unlike, stars with the same *l* and *c* would have different absolute magnitudes or spectral types in the two groups. However, it turns out that the compositions are the same, to within about 10 per cent in the ratio of hydrogen to helium, and about the same in the ratio of hydrogen to heavy elements.

We cannot be certain that this uniformity of initial composition applies to *all* stars. Strömgren points out that the two associations he compared both belong to the same spiral arm of the Milky Way galaxy. It would be interesting to extend the comparison to associations in other spiral arms, and to the Magellanic Clouds.

Finally, Strömgren asks the question: Are there other physical processes in stars that might appreciably distort their evolutionary tracks? If there are, then two stars having identical values of *l* and *c* would not necessarily have equal masses and ages. He mentions differences in rotational velocities and magnetic properties of the stars, and differences resulting from the presence of hydrogen emission lines. The available evidence is not sufficient to ascertain whether these effects are appreciable. To these possibilities we might add mass exchange and mass expulsion in close binary systems like Beta Lyrae and U Cephei. There is in fact other evidence that the evolutionary tracks of members of such binary systems may differ drastically from those of normal single stars.

TO CANOSSA

Nearly 900 years ago, Emperor Henry IV of the Holy Roman Empire crawled on his knees into the presence of Pope Gregory VII at Canossa to do penance and induce the pope to lift the excommunication that had been pronounced against him. Today I "go to Canossa" to do penance before the readers of *Sky and Telescope* for having made a serious slip in my September article on the orbits of visual double stars.

The error was pointed out by Charles Mariano of the Polytechnic Institute of Brooklyn. The plastic-sheet method I described works only if an additional piece of information is already known, for example, the orientation of the line of nodes by the Stewart-Henroteau process. (The diagram at the top of page 551 is to be replaced by the one on page 617 of the October issue.) The line of nodes then serves as a sort of hinge around which the plastic is turned until the desired coincidence of lines occurs. Without this additional information, there are, as Mr. Mariano states, "an infinite number of orientations of the plastic such that the perpendicular lines drawn on it project upon the lines AB and CD in the apparent ellipse."

OTTO STRUVE
Leuschner Observatory

NEW DIRECTOR AT LOWELL

John S. Hall became director of Lowell Observatory, Flagstaff, Arizona, on September 1st. He is the fifth astronomer to head the famous institution founded by Percival Lowell to observe Mars during its 1894 opposition. The other directors have been V. M. Slipher, A. G. Wilson, and E. C. Slipher.

Dr. Hall is a photoelectric specialist, well known for pioneer work in infrared photometry, the polarization of starlight, and atmospheric scintillation. Such fields of observation are of growing importance in the solar-system problems that have always been the main work of Lowell Observatory.

For the last 10 years, Dr. Hall has been at the U. S. Naval Observatory, where he is being succeeded as chief of the astrometry and astrophysics division by K. A. Strand (see page 22).

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 100th meeting of the American Astronomical Society at Madison, Wisconsin, in June, 1958. Complete abstracts will appear in the Astronomical Journal.

High-Altitude Meteoritic Dust

The most efficient means yet developed for collecting dust that enters the atmosphere from outside the earth was reported by P. W. Hodge and J. S. Rinehart, working at the Harvard and Smithsonian Astrophysical observatories. A collecting device of the design sketched here has been carried aloft in airplanes, to levels where the air is relatively free of contamination from terrestrial sources.

Jet aircraft of Edwards Air Force Base in California have made 22 flights into the stratosphere carrying Rinehart collectors. At the plane's maximum altitude, the pilot opens a solenoid-operated shutter, uncovering the six-millimeter intake hole of the collector. The air passes into a collecting chamber two centimeters in diameter, where it deposits any solid particles on a millipore filter supported by a wire screen.

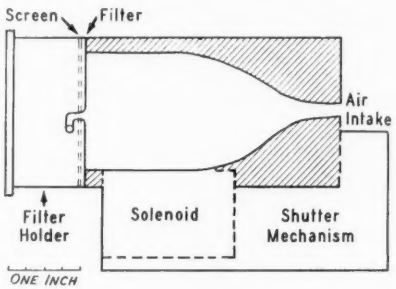
When the plane returns to earth, the filter housing is removed, and fresh filters can be quickly installed without contamination. The collection times have ranged from five minutes to about 3½ hours. At heights above 50,000 feet, the total accumulation during one hour is about 1,000 particles of over 0.002-centimeter diameter.

Microscopic examination of the collected material has revealed several distinct varieties of particles. In addition to those originating within the collector itself, there were semitransparent blobs of terrestrial dust. But the remaining eight per cent of the particles appeared to be of extraterrestrial origin. Some were shiny black chunks, others cindery frameworks of metallic appearance up to 0.02 centimeter across. A small percentage were shiny black spherules, a type already generally recognized as meteoritic from studies of collections made at the earth's surface.

It is planned to have a dozen Rinehart collectors in operation in a few months. Together they will provide large enough samples for detailed chemical analysis.

In another paper presented to the society, C. L. Hemenway and E. F. Fullam, Dudley Observatory, told of their examination of these extraterrestrial particles by electron-microscope and electron-diffraction techniques. The larger of the particles, which they believe to be micrometeorites, show evidence of cratering. This pitting appears to be due to impacts by meteoritic particles of submicron size. Their study shows that these smaller bodies occur in large numbers.

Electron-diffraction examination of the micrometeorites revealed no evidence of crystalline structure. At least some of these bodies were found to be magnetic.



The Rinehart collector is a compact device carried aloft by aircraft to collect micrometeorites, which are deposited on the filter from the stream of air entering the intake.

The nebula IC 405, photographed in blue light by G. H. Herbig of Lick Observatory, with the 36-inch Crossley reflector. The interloping star AE Aurigae makes these dust clouds visible by reflection. North is above, east to the left.

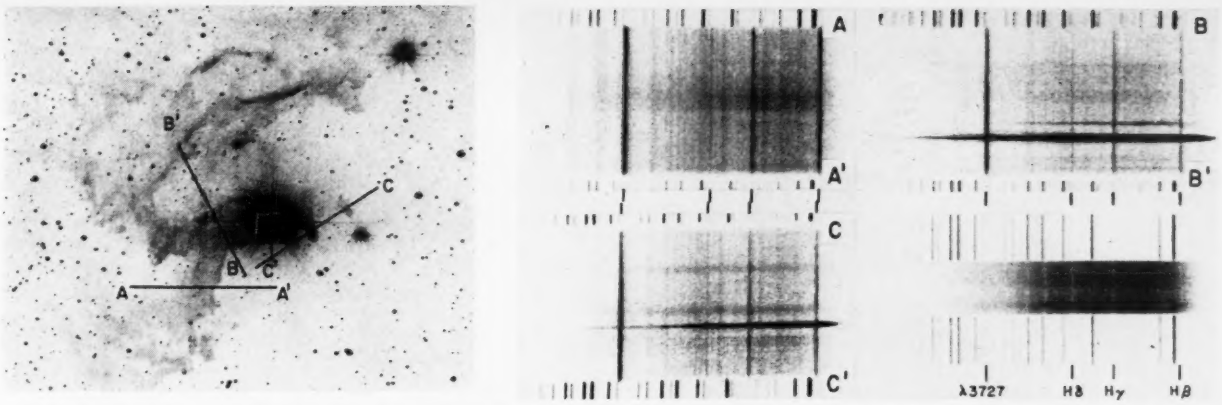
An Unusual Reflection Nebula and the Star AE Aurigae

When a hot star of early spectral type lies inside or very near a gaseous nebula, the strong radiation of the star at very short wave lengths ionizes the atoms in the nebula, which then becomes self-luminous by recombinations of the electrons and ions in the gas. The nebulosity has a spectrum characterized by bright emission lines of hydrogen, oxygen, and other elements.

If dust is involved in the nebulosity, the spectrum may also have a reflection component that mirrors the spectrum of the star itself, while at great distances from the star, where its radiation is too weak to cause the ionization processes, the nebula's spectrum may be entirely of the reflection type.

There is, however, the case of IC 405, which appears to be illuminated by the 6th-magnitude star AE Aurigae, of spectral type *O*9.5. George H. Herbig, Lick Observatory, believes the peculiarities of IC 405 indicate that the star and this nebula have been close together for a relatively short time.

AE Aurigae is one of the early-type objects that is receding with a high velocity from the I Orionis star association (*Sky and Telescope*, March, 1954, page 156). It is moving through the sky at a rate of 128 kilometers per second at a distance from us of about 500 parsecs. Its motion



The direct photograph (left) of IC 405 was taken in blue light by Dr. Herbig, who labeled the locations of the spectrograph slit for the first three spectra at the right. The lower-right spectrum is of the star AE Aurigae. He used the Crossley nebular spectrograph, with a dispersion of 430 angstroms per millimeter and a slit scaling six minutes of arc long. The strips of continuous spectrum are due to the reflection nebula, while lines not extending the full slit length are from the emission nebula. All photographs on these two pages are from Lick Observatory, University of California.

in the line of sight (radial velocity) is about 59 kilometers per second away from us. On the other hand, IC 405 is receding at only about 22 kilometers per second. Thus, AE Aurigae seems to be a recent interloper in the nebulosity.

IC 405 has two distinct components, a complex emission nebulosity and some streamers that appear to be dust. This is illustrated by these two photographs made by Dr. Herbig with the Lick 36-inch Crossley reflector. Both have the same scale and show the same part of the sky.

Almost all of the bright nebulosity shown in the blue photograph (3800 to 5000 angstroms) has a continuous spectrum, except for some filaments north of the star. Compare this appearance to that in the red photograph (6300 to 6750 angstroms), where all of the nebulosity shown has a predominantly emission spectrum.

Representative spectrograms of three sections of IC 405 are reproduced above, together with the spectrum of AE Aurigae (lower right). The respective positions of the slit are indicated on the small picture of the nebula. The dark strips of continuous spectrum are due to parts of the "blue" nebulosity, while the bright lines of hydrogen and ionized oxygen (3727 angstroms) arise in the emission component. Other emission lines are due to the night sky and city lights.

Does the continuous nebulosity consist of dust illuminated by starlight? The most straightforward test fails: Bright hydrogen lines of the emission nebulosity are present to some extent on all the spectrograms, and so mask the possible presence, in the continuous nebulosity, of Balmer absorption lines from ordinary scattering of AE Aurigae's light by dust.

The presence of dust is indicated, however, by an inspection of direct photographs, which show that the distribution of stars in the vicinity of AE Aurigae is not at all uniform. Thus, dust may be causing some absorption of starlight, and this possibility is confirmed by the fact that in all cases the brighter parts of the continuous nebulosity coincide with lanes where there are apparent deficiencies of faint stars. This observation is based on star counts in a photograph taken by Dr. Herbig in the wave-length region 5250-5850 angstroms, where both nebulosities are very faint.

The material responsible for the blue nebulosity probably has very little free gas associated with it, otherwise this would show on the red photograph. This conclusion runs counter to the belief that gas and dust are always associated. Hydrogen 21-cm. line observations would be of considerable interest, to detect the presence of regions of unionized gas in IC 405.

It is noteworthy that none of the dust structure lies directly south of the star. It may not have existed there originally or, since that is the direction from which the star has come, there may have been enough time for the dust particles in that

Compare the facing picture with this red-light exposure of IC 405, in which the dust clouds are not seen, but a wholly different nebular structure of luminous gas is brought out. The star AE Aurigae is the brightest one of this photograph, and is below the center.

direction to have been modified by the star's radiation.

The Lick astronomer postulates the following picture of the association of AE Aurigae and IC 405. The star, in its northward motion, has encountered two nebulae: a large low-density gas cloud which the radiation of the star has ionized, and some dust streamers which only scatter the star's light. As the star is moving very rapidly, the dust has not yet had time to change its properties in the new radiation field. Given sufficient time, the nebula will presumably be greatly modified.

QUESTIONS... FROM THE S+T MAILBAG

Q. In what constellation is Barnard's "runaway" star?

A. It is in Ophiuchus, at right ascension $17^h\ 55^m.7$, declination $+4°\ 35'$ (1959.0 co-ordinates), about 0°.6 west and 0°.2 north of 5th-magnitude 66 Ophiuchi. Barnard's star has the largest proper motion known, carrying it one minute of arc northward every six years. Of visual magnitude 9.5, this red dwarf has a spectrum of type *M*5, and is only seven light-years distant.

Q. Why can't we see the other side of the moon from the earth?

A. The moon has a permanent tidal bulge toward the earth, so that as it revolves around us it keeps the same side toward us. Thus, its periods of revolution and rotation are locked together, and a lunar day is a month long.

Q. How much of the moon's surface has actually been seen?

A. Small periodic variations in aspect, known as librations, permit us to look around the edges and over the top and bottom of the hemisphere of the moon that faces us, so that 59 per cent of its surface has been observed.

Q. What is the annual displacement of the equinox due to precession?

A. This displacement is 50.27 seconds of arc per year along the ecliptic. Its component in right ascension is 3.07 seconds of time, in declination 20.04 seconds of arc.

Q. Why will a 2-inch telescope show 9th- or 10th-magnitude stars, while a 15-inch will only show slightly more than four magnitudes fainter?

A. Four magnitudes represent a brightness ratio of about 40; a 15-inch telescope gathers about 50 times as much light as a 2-inch.

Q. Which asteroid was named after an ocean steamer?

A. No reader has yet answered this query by Owen Gingerich on page 517 of September, 1957. Perhaps the allusion is to 724 Hapag, which spells the German initials of the Hamburg-America Line.

W. E. S.

NEWS NOTES

COMET BURNHAM-SLAUGHTER

The fifth comet discovered in 1958 was found at Lowell Observatory, Flagstaff, Arizona, on September 7th by R. Burnham, Jr., and by C. Slaughter. It was a diffuse 14th-magnitude object in the constellation Equuleus, moving slowly westward.

Preliminary calculations of the orbit of Comet 1958e have been made by Dr. Elizabeth Roemer, at the U. S. Naval Observatory's Flagstaff station, from observations on September 7th, 15th, and 21st. They indicate that the new object will be closest to the sun in March, 1959, the minimum distance being 1.65 astronomical units. However, so far the apparent motion of the comet has differed little from a great circle on the celestial sphere, and this makes any orbit computations uncertain.

The predicted right ascension and declination are $20^h\ 21^m.2$, $+14°\ 56'$ (1958.0) for November 3rd; and $20^h\ 29^m.7$, $+18°\ 21'$ on December 3rd. The object should be brightening.

This is Mr. Burnham's third comet. He discovered 1958a on February 21st, and less than four months earlier was a co-discoverer of Comet 1957f.

SOUTHERN OBSERVER OF VARIABLE STARS

Since most observatories, professional and private, are located in northern latitudes, the important work of maintaining visual observations of variable stars in the far southern sky is carried out by relatively few persons. According to the July *Monthly Notes* of the Astronomical Society of Southern Africa, R. P. de Kock of Capetown has now passed the 100,000 mark in his estimates of variable star magnitudes. He began this work in 1933, and his annual total has averaged about 6,000 since 1950. Most of Mr. de Kock's observing is carried out with the 6-inch refractor of the Royal Cape Observatory.

ANTIREFLECTION COATINGS FOR INFRARED OPTICS

Infrared spectroscopy has become a valuable tool of astronomy, but at very long wave lengths celestial bodies other than the sun are weak sources, making improved observing techniques highly desirable. Today rather large pieces of infrared-transparent germanium and silicon can be made for use as infrared windows and image-forming elements. At Ft. Belvoir, Virginia, J. T. Cox and G. Hass have been developing thin antireflection coatings for these materials.

They have succeeded in preparing very durable coatings which provide a transmission of 98 per cent or better at any desired wave length in the infrared up to about 15 microns. Evaporated films of silicon monoxide appear best for the near infrared. For the region of eight to 14 microns, where silicon monoxide is not sufficiently transparent, zinc sulfide is very suitable. Hitherto, coatings of zinc sulfide had not proved durable, but it has now been found that careful glow-discharge cleaning just before deposition on material heated to at least 150° centigrade cures this difficulty.

Details of this work are given in the October, 1958, *Journal* of the Optical Society of America.

STARS OF CLASS R

The relatively rare red stars of type *R* have spectra characterized by bands of carbon and cyanogen. An extensive survey of their properties has been completed at Leander McCormick Observatory by G. L. Vandervort. With a photoelectric photometer he has measured the magnitudes and colors of 98 of these objects, finding that the color index increases from +1.2 for *R*0 stars to +2.1 for *R*8 ones. Of the 98 stars, 21 are variable in brightness.

From the proper motions of these stars (determined in 41 cases by Dr. Vandervort himself) and their published radial velocities, he could find their average luminosity. The visual absolute magnitude is about +0.4 for *R*0 and *R*2 stars, and −1.1 for those with *R*5 and *R*8 spectra.

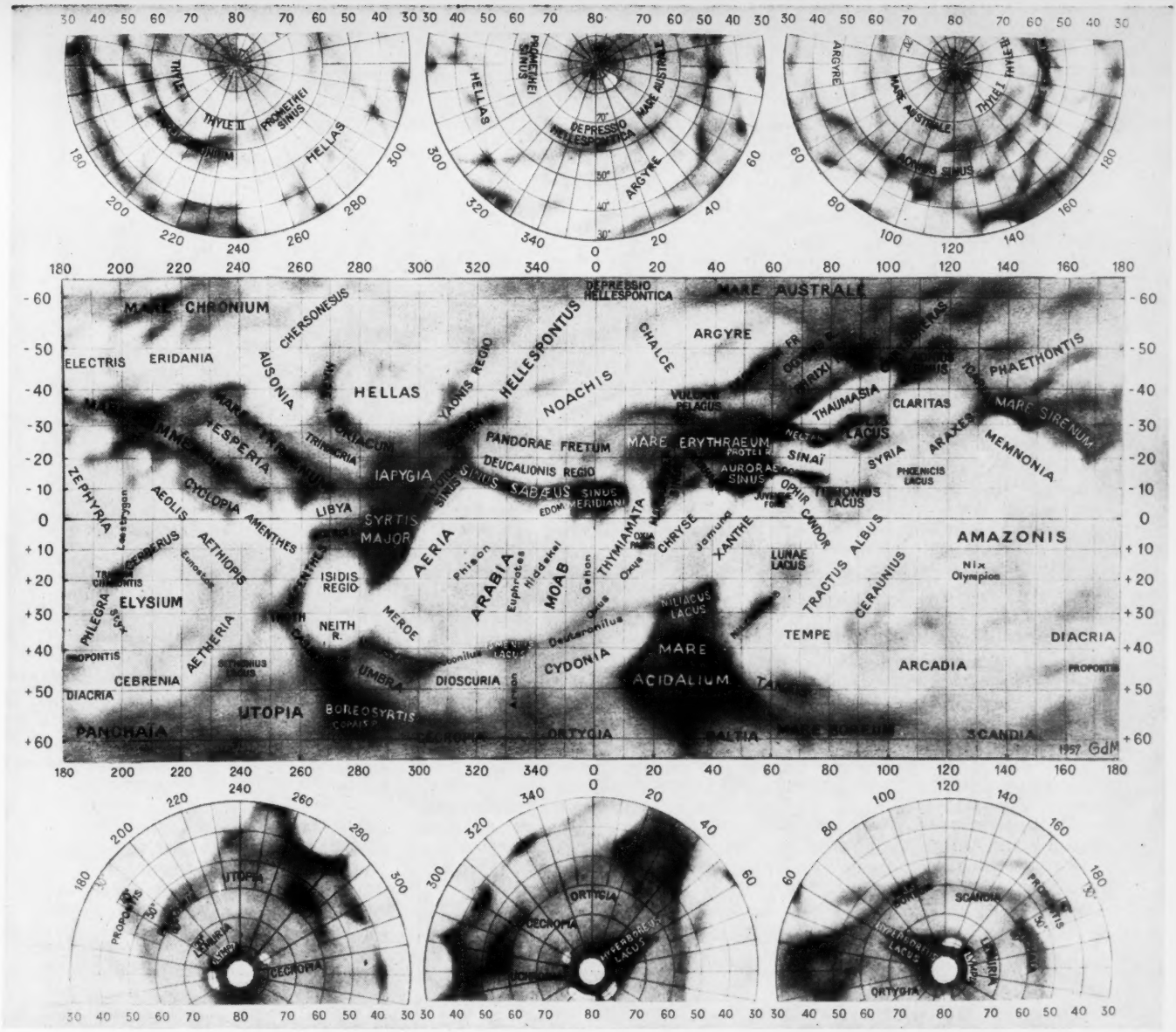
Dr. Vandervort's investigation continues the long series of studies at McCormick Observatory concerning the systematic motions of stars having different spectral types. His classifications were made on A. N. Vyssotsky's fine collection of objective-prism spectrograms, taken with a 10-inch refractor, which cover the entire sky visible from the observatory at Charlottesville, Virginia.

WASHINGTON APPOINTMENT

K. A. Strand has been named to direct the astrometry and astrophysics division of the U. S. Naval Observatory, Washington, D. C. The Danish-born astronomer had been director of Dearborn Observatory, Northwestern University, where he specialized in precise photographic measurements of double stars. Dr. Strand will continue his connection with the University of Chicago as a research associate with the rank of professor in the astronomy department.

IN THE CURRENT JOURNALS

THE TAILS OF COMETS, by Ludwig F. Biermann and Rhea Lüst, *Scientific American*, October, 1958. "It has long been assumed that the gases of a comet tail are pushed away from the comet by the pressure of light from the sun. It now appears that many tails are caused by a wind of charged particles."



The International Astronomical Union's map of Mars, showing the 128 proper names officially adopted for large, fairly permanent regions. Drawn by G. de Mottoni, these charts and the one on page 25 were based on photographs taken at Pic du Midi Observatory during six oppositions of Mars from 1941 to 1952. (Some lettering on this photograph has been retouched for reproduction purposes, and a few misspelled names corrected.)

The New IAU Nomenclature for Mars

JOSEPH ASHBROOK, *Harvard College Observatory*

OBSERVERS of the planet Mars have long been burdened by the unwieldy system of names for its dark and bright surface markings. In an effort to assist Martian studies, the International Astronomical Union adopted a simplified and more convenient system at its Moscow assembly in August.

The traditional names for the surface features are an outgrowth of G. V. Schiaparelli's mapping of Mars in 1877 with the 8-inch refractor of the Milan observatory. As the Italian astronomer made his sketches at the telescope, he assigned to each new feature that he drew some geographical name, usually in Latin or Greek form. Thus arose such familiar Martian designations as Hellas (Greece) and Ausonia (Italy). Newly discovered "canals" he named after rivers, for example Indus, Ganges, and Nilus. The terrestrial counterparts of most of these names can be identified with the aid of an atlas of classical geography.

As Schiaparelli continued to observe Mars at opposition after opposition, later with an 18-inch refractor, his list of names grew. Hundreds of other designations in the same spirit were added by Percival Lowell and by E. M. Antoniadi. The latter's 1930 book, *La Planète Mars*, contains a map based on all previous observations, with over 550 named formations. Still more recent additions have been made, for example those by the Association of Lunar and Planetary Observers.

This unsystematic nomenclature has now begun to break down under its own weight. There are far too many arbitrary names to be conveniently remembered. Different designations are sometimes used for the same formation by different au-

Fact Sheet on the Planet Mars

Characteristics of the Planet	
North celestial pole of Mars (1950 co-ordinates)	R.A. $21^h\ 07^m.2$ Dec. $+53°.0$
Inclination of Martian equator to its orbital plane	24°.8
Length of Martian day	$24^h\ 37^m\ 22^s.7$
Equatorial diameter	4,200 miles
Length of one degree of latitude on Mars' surface	37 miles

*Characteristics of the Orbit**	
Mean distance from the sun	1.5237 A.U.
Eccentricity of the orbit	0.0934
Longitude of perihelion	335° 17′
Inclination of the orbit	1° 51′
Longitude of ascending node	49° 14′
Martian year	$686^d\ 23^h\ 30^m\ 41^s$

Seasons in the Northern Hemisphere of Mars begin when the planet is at the following heliocentric longitudes: spring, 84°.0; summer, 174°.0; autumn, 264°.0; winter, 354°.0.

*Orbital elements are values for 1958.

thors, and in other cases the exact identity of the marking to which a particular name applies remains uncertain. Also, since all surface features of Mars are more or less subject to change, numerous names apply to temporary minor details that disappeared many years ago.

Hitherto, any one designation system has not served equally the needs of observers using instruments of widely differing resolving power. When very large telescopes are used to observe Mars under favorable seeing conditions, the named dark areas are resolved into complex fine structures.

The International Astronomical Union in 1952 set up a special Subcommission 16a to reform the Martian nomenclature. Its chairman was the veteran French planetographer G. Fournier. After his death in 1954, the project was continued by A. Dollfus of Meudon Observatory. The other members of the subcommission were H. Camichel (France), G. P. Kuiper and G. Van Biesbroeck (U. S. A.), G. de Mottoni (Italy), A. F. O'D. Alexander and M. B. B. Heath (England), and N. P. Barabashev (U. S. S. R.). Many other planetary observers offered their recommendations. At the 1958 IAU congress, the reformed system of Martian names proposed by this group was formally adopted.

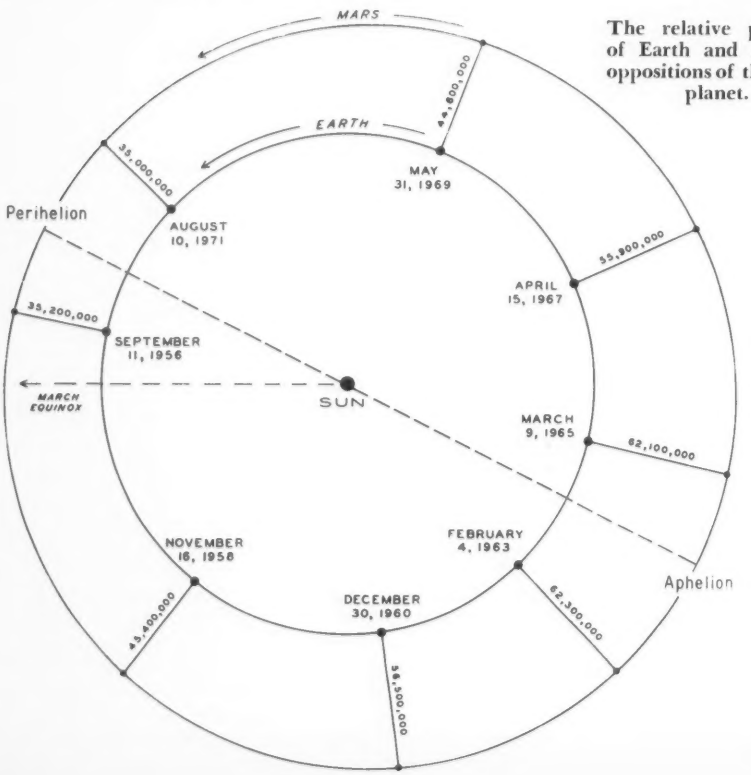
The aims of the new system are:

1. To keep the nomenclature simple even if future observations of Mars reveal much more detail.

2. To be convenient for photometric, spectroscopic, or polarimetric observers who can isolate only fairly extended areas of the planet's surface. Such studies are often undertaken by scientists not familiar with the traditional Martian names.

3. To avoid drastic changes from earlier usage by making the system understandable by anyone acquainted with the previous designations.

To achieve these aims, **large regions** will retain the proper names already in use. These are the quasi-permanent features that preserve their identities over many years, despite seasonal and other changes. Each such proper name is an over-all designation for a region as a whole.



The relative positions of Earth and Mars at oppositions of the latter planet.

The number of official proper names is thus reduced to 128, distributed almost uniformly over the surface of Mars. These areas were selected from the list of 404 reported to the IAU by Fournier, which in turn was a pruning of Antoniadi's 558 in his 1930 list.

The IAU subcommission has introduced a few changes and additions to existing names:

1. Thaumasia Felix is now simply *Thaumasia.*

2. The hitherto unnamed bright region centered on longitude 75°, latitude −20°, has been named *Sinai,* because of its nearness to Mare Erythraeum (the Red Sea).

3. Another nameless region, at longitude 100°, latitude −20°, near Phoenicis Lacus, has been called *Syria.*

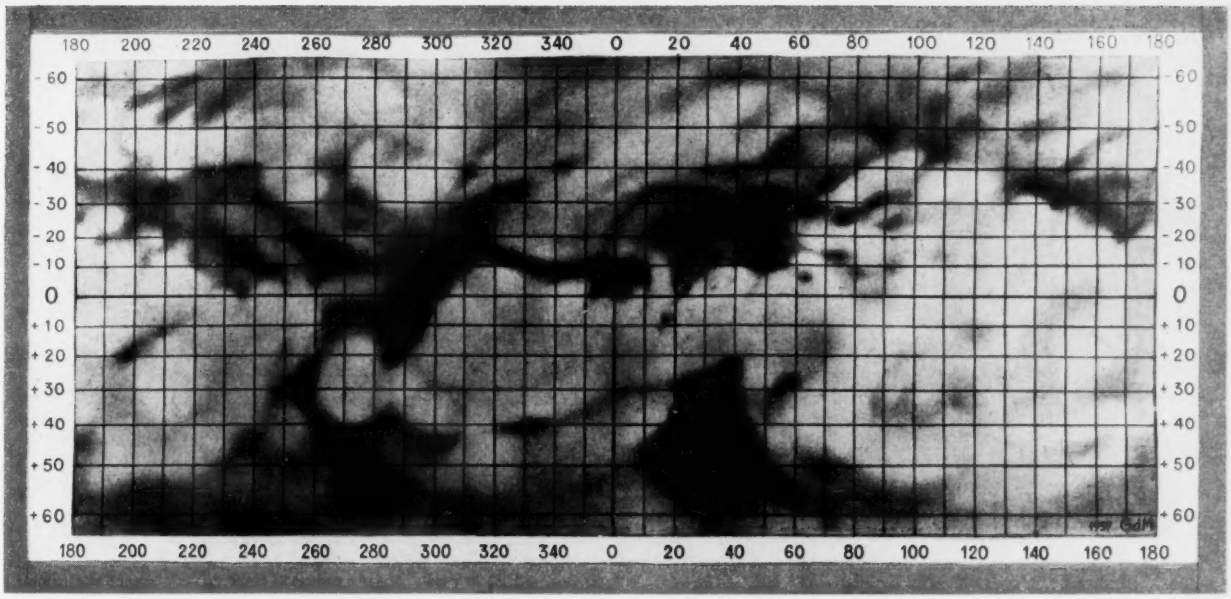
4. Of the two areas known previously as Ausonia Australis and Ausonia Borealis, the former is now to be called *Ausonia,* the latter *Trinacria* (Sicily).

The main novelty of the new system is that **small details** are henceforth to be known not by names but by their approximate Martian longitudes and latitudes. For example, 189°, +20° will designate a marking whose longitude is 189° and latitude +20°. These labels have the advantage over the older names of indicating location on the planet's surface.

To facilitate the use of the new Martian nomenclature, the IAU subcommission has compiled a catalogue of the 128 adopted names, and a chart identifying them. For the smaller details, maps with only the necessary co-ordinate grid were supplied. These charts are reproduced in *Sky and Telescope* at the request of the IAU, to make them available to observers during the present close approach of Mars to the earth. The next volume of the IAU *Transactions,* which will contain the full report on Martian nomenclature, will not be published for one or two years.

The maps were drawn by de Mottoni from the many exquisite photographs of Mars secured at Pic du Midi Observatory during the oppositions of 1941, 1943, 1946, 1948, 1950, and 1952. He first made six charts, one for each year, and from these compiled a final map, showing surface markings that appeared reasonably permanent over the interval 1941-52.

Special care was taken by Dollfus and his coworkers in providing an accurate co-ordinate grid for the maps. All the better measurements of Martian longitudes and latitudes were collected and



The de Mottoni map of Mars printed without names, to facilitate reading grid co-ordinates of minor details.

compared. The orientation of the grid is defined by Camichel's recent and precise determination of the location of the north pole of Mars. He found that the rotational axis of the planet, when prolonged, intersects the celestial sphere at right ascension $21^h\ 07^m.2$, declination $+53°.0$ (1950 co-ordinates). His result, which supplants all previous work, is from measurements of Pic du Midi photographs from 1941 to 1954. This study also gave 9".33 as the diameter of Mars when viewed from a distance of one astronomical unit; this corresponds to 4,200 miles.

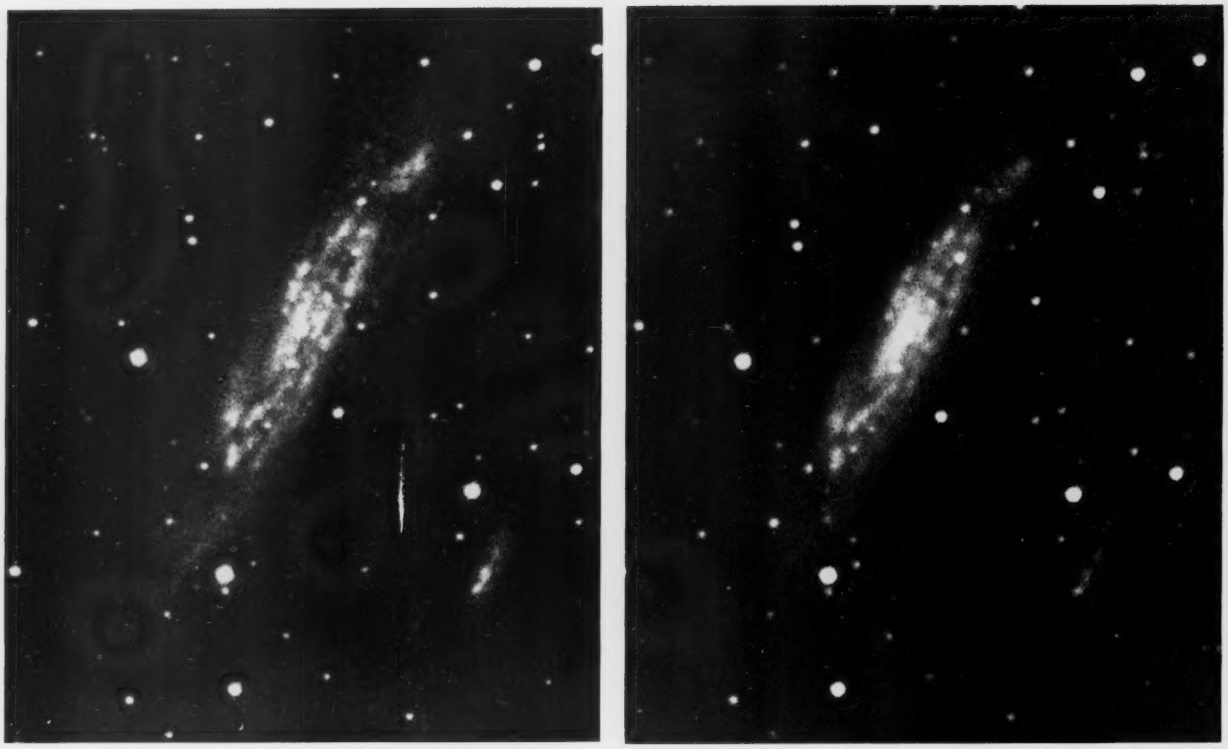
While the new Martian nomenclature was adopted unanimously by the astronomers meeting at Moscow, some criticisms have been expressed by several other experienced observers of the red planet. The map is perhaps the most reliable available, but it shows only about the amount of detail visible to an experienced observer in a 6-inch telescope. The needs of workers with considerably larger instruments may not be adequately met.

There are a number of discrepancies between map names and those in general use that could cause confusion. For example, the designation Thoth has been transferred to the marking Nodus Laocoontis, while the useful name Coloe Palus has been dropped, this marking now becoming part of Nilosyrtis. Perhaps the IAU will take action to correct such discordances.

Serious observers of Mars would welcome publication of a collated list of names, giving for each marking the synonyms used by Schiaparelli, Antoniadi, Lowell, and others. In any event, it would be well for Mars observers to indicate in their reports of observations whether or not they are using the IAU map and nomenclature as a basis for identifications.

The 128 Named Martian Features

Acidalium Mare (30°, +45°)
Aeolis (215°, −5°)
Aeria (310°, +10°)
Aetheria (230°, +40°)
Aethiopis (230°, +10°)
Amazonis (140°, 0°)
Amenthes (250°, +5°)
Aonius Sinus (105°, −45°)
Arabia (330°, +20°)
Araxes (115°, −25°)
Arcadia (100°, +45°)
Argyre (25°, −45°)
Arnon (335°, +48°)
Aurorae Sinus (50°, −15°)
Ausonia (250°, −40°)
Australe Mare (40°, −60°)
Baltia (50°, +60°)
Boreosyrtis (290°, +55°)
Boreum Mare (90°, +50°)
Candor (75°, +3°)
Casius (260°, +40°)
Cebrenia (210°, +50°)
Cecropia (320°, +60°)
Ceraunius (95°, +20°)
Cerberus (205°, +15°)
Chalce (0°, −50°)
Chersonesus (260°, −50°)
Chronium Mare (210°, −58°)
Chryse (30°, +10°)
Chrysokeras (110°, −50°)
Cimmerium Mare (220°, −20°)
Claritas (110°, −35°)
Copais Palus (280°, +55°)
Coprates (65°, −15°)
Cyclopia (230°, −5°)
Cydonia (0°, +40°)
Deltoton Sinus (305°, −4°)
Deucalionis Regio (340°, −15°)
Deuteronilus (0°, +35°)
Diacria (180°, +50°)
Dioscuria (320°, +50°)
Edom (345°, 0°)
Electris (190°, −45°)
Elysium (210°, +25°)
Eridania (220°, −45°)
Erythraeum Mare (40°, −25°)
Eunostos (220°, +22°)
Euphrates (335°, +20°)
Gehon (0°, +15°)
Hadriacum Mare (270°, −40°)
Hellas (290°, −40°)
Hellespontica Depressio (340°, −6°)
Hellespontus (325°, −50°)
Hesperia (240°, −20°)
Hiddekel (345°, +15°)
Hyperboreus Lacus (60°, +75°)
Iapygia (295°, −20°)
Icaria (130°, −40°)
Isidis Regio (275°, +20°)
Ismenius Lacus (330°, +40°)
Jamuna (40°, +10°)
Juventae Fons (63°, −5°)
Laestrygon (200°, 0°)
Lemuria (200°, +70°)
Libya (270°, 0°)
Lunae Lacus (65°, +15°)
Margaritifer Sinus (25°, −10°)
Memnonia (150°, −20°)
Meroe (285°, +35°)
Meridiani Sinus (0°, −5°)
Moab (350°, +20°)
Moeris Lacus (270°, +8°)
Nectar (72°, −28°)
Neith Regio (270°, +35°)
Nepenthes (260°, +20°)
Nereidum Fretum (55°, −45°)
Niliacus Lacus (30°, +30°)
Nilokeras (55°, +30°)
Nilosyrtis (290°, +42°)
Nix Olympica (130°, +20°)
Noachis (330°, −45°)
Ogygis Regio (65°, −45°)
Olympia (200°, +80°)
Ophir (65°, −10°)
Ortygia (0°, +60°)
Oxia Palus (18°, +8°)
Oxus (10°, +20°)
Panchaia (200°, +60°)
Pandorae Fretum (340°, −25°)
Phaethontis (155°, −50°)
Phison (320°, +20°)
Phlegra (190°, +30°)
Phoenicis Lacus (110°, −12°)
Phrixi Regio (70°, −40°)
Promethei Sinus (280°, −65°)
Propontis (185°, +45°)
Protei Regio (50°, −23°)
Protonilus (315°, +42°)
Pyrrhae Regio (38°, −15°)
Sabaeus Sinus (340°, −8°)
Scandia (150°, +60°)
Serpentis Mare (320°, −30°)
Sinai (70°, −20°)
Sirenum Mare (155°, −30°)
Sithonius Lacus (245°, +45°)
Solis Lacus (90°, −28°)
Styx (200°, +30°)
Syria (100°, −20°)
Syrtis Major (290°, +10°)
Tanais (70°, +50°)
Tempe (70°, +40°)
Thaumasia (85°, −35°)
Thoth (255°, +30°)
Thyle I (180°, −70°)
Thyle II (230°, −70°)
Thymiamata (10°, +10°)
Tithonius Lacus (85°, −5°)
Tractus Albus (80°, +30°)
Trinacria (268°, −25°)
Trivium Charontis (198°, +20°)
Tyrrhenum Mare (255°, −20°)
Uchronia (260°, +70°)
Umbra (290°, +50°)
Utopia (250°, +50°)
Vulcani Pelagus (15°, −35°)
Xanthe (50°, +10°)
Yaonis Regio (320°, −40°)
Zephyria (195°, 0°)



The galaxy NGC 4835, photographed with the 74-inch Radcliffe Observatory telescope. The blue-light picture at the left was taken without a filter on an Eastman 103a-O plate, exposed for one hour on June 6, 1956. At the right is a 90-minute exposure in red light, made with a 103a-E plate behind an Ilford 205 filter, on July 2, 1956. Comparison of the pictures indicates that the high-contrast details are relatively blue in color.

Among Southern Galaxies—X

THESE three pictures conclude the series begun in February, 1958, of reproductions from the Cape Photographic Atlas of Southern Galaxies. Two of these views depict NGC 4835, and the facing one is of NGC 1365.

NGC 4835, shown in blue and red light at the top of this page, is so strongly foreshortened that it is rather difficult to classify, though David S. Evans assigns it to type Sb. This kind of system is not uncommon — a spiral structure defined by discrete blobs of luminosity separated by strongly contrasting dark lanes, the whole surrounded by much fainter arms.

The system covers a sky area 3.0 by 0.6 minutes of arc. It is located in Centaurus at right ascension $12^h\ 55^m.3$, declination $-45°\ 59'$ (1950 co-ordinates), and is plotted in the Skalnate Pleso *Atlas of the Heavens*. The galaxy is about 16 degrees from the central line of the Milky Way, in a latitude so low that considerable light absorption is probable. Its magnitude is given as 12.5 in the Shapley-Ames catalogue.

This month's feature picture is of NGC 1365, a magnificent barred spiral and one of the most conspicuous members of the Fornax cluster. However, the distance is probably of the order of 20 million light-years. Thus, this system may be in front of the Fornax group rather than in it, according to G. de Vaucouleurs.

Located at $3^h\ 31^m.8$, $-36°\ 18'$, about 53 degrees below the galactic plane, NGC 1365 is a large, typical barred spiral of intermediate type SB(s)b, according to the de Vaucouleurs classification system described on page 582 of the October, 1957, issue. The bar is foreshortened, since the plane of the spiral is inclined to our line of sight.

Note the characteristic pattern of dark lanes in the lens and the very bright nucleus, where short exposures disclose an innermost spiral pattern of bright and dark matter. The spiral arms are partly resolved into stars of the 19th magnitude or fainter, with many brighter emission knots. (For a low-resolution photograph taken with the 30-inch reflector at Mount Stromlo Observatory, see page 522 of the September, 1957, issue.)

In his list of the 20 bright southern galaxies (page 525, September, 1957), Dr. de Vaucouleurs gives the total photographic magnitude of NGC 1365 as 9.8, compared to 11.2 assigned in the Shapley-Ames catalogue. The galaxy's inner parts measure 4.8 by 3.3 minutes of arc: the over-all size is 11.7 by 6.8 minutes.

The spectrum of NGC 1365 has been observed at Mount Stromlo Observatory, but the Doppler red shift is still unknown.

The 24 photographs comprising the first part of the Cape Photographic Atlas of Southern Galaxies have been reproduced by permission of R. H. Stoy, director of the Royal Cape Observatory. A complete set, in which each 10-by-12-inch print is mounted on heavy cardboard with photographic exposure data and descriptive notes on the back by Dr. Evans, may be purchased for £15 directly from the Royal Observatory, Cape of Good Hope, South Africa.

FACING PICTURE: The barred spiral NGC 1365 in Fornax, photographed with the 74-inch reflector at Radcliffe Observatory, Pretoria, South Africa, on October 23, 1954. For this one-hour exposure in blue light, an Eastman 103a-O plate was used without a filter. Note the marked central zigzag, a feature common in barred spirals. The scale is about 2.1 minutes of arc per millimeter. These three pictures are courtesy the Royal Cape Observatory, Union of South Africa.

OBSERVING THE SATELLITES

Twelve Months of Optical Tracking

A DAILY AVERAGE of 20 observational reports from established optical stations throughout the world has come in to the Smithsonian Astrophysical Observatory during the first year of the satellite-tracking program. The number of measurements of positions at known times is considerably greater. Some photographs, for example, may yield dozens of individual observations from a passage.

Volunteer observers at 116 stations in the United States and 122 abroad made 6,816 visual observations of satellites up to October 1, 1958. The 12 Baker-Nunn camera installations over the world secured more than 500 photographs, and many were obtained with other kinds of cameras before the special satellite-tracking instruments went into operation. The banner month was August, 1958, when 1,595 observational reports were received — 1,392 of them by volunteers.

As the table on page 29 shows, most of the visual sightings were of the relatively bright Russian satellites, for they may be seen over a wide range of latitudes. The Baker-Nunn cameras, all situated in low latitudes, have taken about as many photographs of American as of Russian satellites.

Promptness in transmitting observations to the computing center in Cambridge, Massachusetts, is essential to the success of the program, because the orbit of each object is changing, sometimes very rapidly. Virtually all preliminary reports have been received within a few hours of the observation, ordinarily by wire. More complete reports, used for definitive orbit computations, have arrived within days. The rapid and unhindered transmission of this scientific data across most international boundaries has been of the utmost importance to the optical tracking program.

At Cambridge, the stream of optical observational data is processed by a high-speed digital computer. First, a preliminary set of orbital elements is derived for a satellite. Then the computer compares each new observation with the preliminary predictions to screen out grossly erroneous data, and uses the rest to obtain fresh orbital elements. As a rule, such corrected elements are derived twice weekly during the lifetime of each object.

Next, the future path of the satellite is predicted from the improved elements. One of the several present forms of the Smithsonian ephemerides is reproduced here. Search ephemerides of this and other types are distributed to tracking stations for scheduling new observations. As long as a satellite remains aloft, there are many repetitions of this cycle: from observations to corrected orbit elements to new ephemerides to new observations.

SMITHSONIAN ASTROPHYSICAL OBSERVATORY, CAMBRIDGE, MASSACHUSETTS

September 3, 1958

SATELLITE 1958 EPSILON

These predictions for Satellite 1958 Epsilon are based on the following orbital elements:

T_o = Aug. 23.78067, times are in days, U.T.
Right ascension of ascending node = 322°.483 - 3°.562 $(t-T_o)$
Argument of perigee = 129°.470 + 2°.895 $(t-T_o)$
Inclination = 50°.33
Perigee distance = 1.0408 earth's equatorial radii
Time of perigee crossing = Aug. 23.78067 + .07601620N - 8.8 x $10^{-7}N^2$

SATELLITE 1958 EPSILON

EQUATOR S-N TIME (UT)	LONG. (W)	LAT.	FOR OTHER LATITUDES SOUTH-NORTH TIME CORR.	LONG. CORR.	HT. (MI)	BEAR. (N-E)	NORTH-SOUTH TIME CORR.	LONG. CORR.	HT. (MI)	BEAR. (N-E)
			SEPTEMBER 9, 1958							
1 7	99.8	50	29	-71.7	707	81.2	33	-92.6	571	98.8
2 56	127.3	45	24	-49.4	873	63.0	38	-115.0	427	116.9
4 45	154.9	40	21	-38.5	970	54.6	40	-126.1	353	125.2
6 34	182.4	20	10	-14.9	1209	39.9	48	-150.5	199	139.5
8 22	210.0	0	0	0.	1299	36.5	54	-166.3	162	142.8
10 11	237.5	-20	-10	14.9	1246	39.9	-49	150.2	222	139.5
11 60	265.1	-40	-21	38.5	1032	54.5	-41	125.9	400	125.3
13 49	292.6	-45	-24	49.3	939	62.9	-38	114.8	481	116.9
15 38	320.2	-50	-30	71.5	773	81.2	-34	92.4	634	98.8
17 26	347.7									
19 15	15.3									
21 4	42.8									
22 53	70.4									
			SEPTEMBER 10, 1958							
0 42	97.9	50	29	-71.6	734	81.2	33	-92.5	597	98.8
2 30	125.5	45	24	-49.4	900	62.9	38	-114.9	449	116.9
4 19	153.0	40	21	-38.5	996	54.5	41	-126.0	372	125.2
7 57	208.1	20	10	-14.9	1224	39.9	48	-150.4	208	139.5
9 46	235.7	0	0	0.	1299	36.5	54	-166.2	162	142.8
11 35	263.2	-20	-10	14.9	1229	39.9	-48	150.3	211	139.5
13 23	290.7	-40	-21	38.5	1005	54.5	-41	125.9	379	125.2
15 12	318.3	-45	-24	49.4	910	62.9	-38	114.9	457	116.9
17 1	345.8	-50	-29	71.6	744	81.2	-34	92.5	606	98.8
18 50	13.4									
20 38	40.9									
22 27	68.4									

SITUATION REPORT
SATELLITE 1958 EPSILON
SEPTEMBER 11, 1958
COMPUTED FOR 0 16 UT

INCLINATION	50.33 DEG.
PRECESSION	-3.562 DEG./DAY
NODAL PERIOD	108.77 MIN.
RATE OF CHANGE OF PERIOD	-0.034 MIN./DAY
LATITUDE OF PERIGEE	-1.65 DEG.
ARGUMENT OF PERIGEE	182.14 DEG.
RATE OF CHANGE OF ARGUMENT OF PERIGEE	2.89 DEG./DAY
HEIGHT OF PERIGEE	161.7 MILES
HEIGHT OF APOGEE	1296.9 MILES
RATE OF CHANGE OF HEIGHT OF APOGEE	-1.9 MILES/DAY

An excerpt from a typical ephemeris for a satellite, in this case Explorer IV. In the first two columns, the times and locations of northward crossings of the equator are listed. On September 9th, for example, this first occurs at 1:07 UT, in longitude 99°.8 west. From succeeding columns, the situation at other latitudes may be derived. On the 9th, the first northward crossing of latitude 50° north occurs 29 minutes later, or 1:36 UT, at a longitude 71°.7 farther east, namely 28°.1 west. The height is 707 miles, and the direction of travel 81°.2 east of north. The last four columns apply similarly to southward crossings.

NASA Plans for Space Research

RESPONSIBILITY for America's non-military space research and exploration was transferred to the National Aeronautics and Space Agency (NASA) on October 1st by executive order. This new civilian agency thus assumes control of all scientific satellite programs, including the Navy's Project Vanguard and the Army and Air Force lunar probe experiments.

Its tasks also involve the development of some rockets more powerful than are required by the Department of Defense. These include a million-pound-thrust single-chamber engine, nuclear-powered devices, and rockets powered by exotic fuels.

One of the satellites planned by the NASA will carry a flashing light, so that its location can be observed at the same instant from widely separated tracking stations, for geodetic triangulation. Observations of conventional satellites must be timed by radio time signals, such as

OPTICAL OBSERVATIONS OF SATELLITES*

Satellite	Name	Launched	Moonwatch U.S.A.	Moonwatch Foreign	Visual Total	Baker-Nunn	Super-Schmidt	Camera Total	Totals
1957α	Sputnik I	Oct. 4	524	348	872	6	—	6	878
1957β	Sputnik II	Nov. 3	1380	1017	2397	11	21	32	2429
1958α	Explorer I	Jan. 31	160	129	289	218	4	222	511
1958β	Vanguard I	Mar. 17	15	8	23	—	2	2	25
1958γ	Explorer III	Mar. 26	39	20	59	4	6	10	69
1958δ	Sputnik III	May 15	1992	1049	3041	244	9	253	3294
1958ε	Explorer IV	July 26	100	35	135	52	—	52	187
			4210	2606	6816	535	42	577	7393

*Including observations of carrier rockets and nose cones from October 4, 1957, to October 1, 1958. Visual totals are individual timed positions, while camera totals are for photographs, some containing many exposures. This summary may not be complete.

those broadcast by WWV, but they may be uncertain by 0.002 second or more because the precise path length of the radio waves from the transmitter to the receiver is unknown. During such an interval a five-mile-per-second satellite travels about 50 feet, causing too great an uncertainty for geodetic work. Use of the flashing beacon would permit unambiguous simultaneous observations for triangulation purposes.

Time itself will be investigated in another moonlet proposed by the agency. It would carry an atomic clock, the rate of which depends upon resonance within the atom. The speed of the satellite in its orbit would be great enough to affect the atomic processes and alter the rate of the clock, thereby providing a check on Einstein's theory of relativity.

Upper-air densities, the aurora, the airglow (self-light of the night sky) are all important subjects for future satellite experiments. For the density studies, a metalized inflatable sphere that can attain a diameter of 100 feet will be launched. It will also serve as a radar target for studies of the transmission of radio waves. A scaled-down model of this device was test-fired from Wallops Island, Virginia, on September 11th, but it failed to inflate.

Additional experiments will extend Explorer studies of intense high-altitude cosmic radiation, a potentially serious hazard to manned spaceflight. According to Herbert F. York, chief scientist of the Defense Department's Advanced Research Projects Agency, manned flight above 300 miles may be best attempted from the north or south polar regions, taking advantage of the effect of the earth's magnetic field.

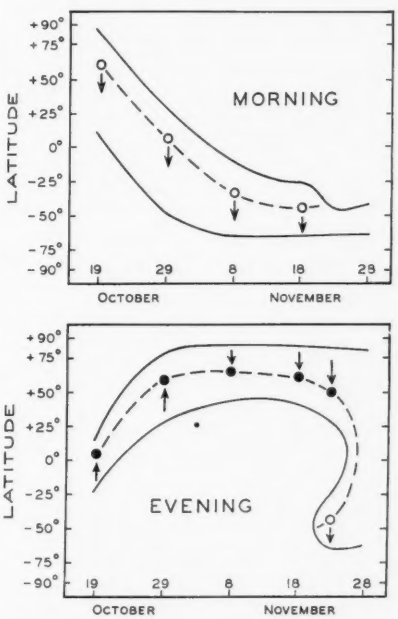
A Short-Lived Vanguard

SEVENTH in the Vanguard program, the satellite launched at 15:38 UT on September 26th from Cape Canaveral, Florida, made "one or at most a limited number of passes around the earth at very low altitudes," according to an announcement by the U. S. Navy. Apparently the rocket did not achieve the height or velocity needed for a sustained orbit, and the satellite was consumed by the resistance of the atmosphere. The 20-inch sphere, weighing 22 pounds, had been instrumented with photocells for observing the earth's cloud cover.

After the launching, Minitrack stations at Grand Turk and at Antigua in the British West Indies, also at Esselen Park in South Africa, received radio signals from the satellite, but none were detected by the San Diego, California, tracking station. A short while later, signals on the satellite's wave length were reported from Ft. Belvoir, Virginia, and from Havana, Cuba.

A few hours later, at 18:13:57 UT, one Moonwatch observer at Bloemfontein, South Africa, saw an object through broken clouds in a direction coinciding with preliminary computations of the orbit by the Naval Research Laboratory. However, there were no further visual sightings, nor were any later radio signals received, in spite of attempts to interrogate the telemetry transmitter within the satellite.

Computations based on radar and radio tracking after rocket burnout show the trajectory was not high enough to produce a permanent orbit.



As satellite 1958δ1, the rocket carrier of Sputnik III, loses altitude rapidly, its period will become progressively shortened in the interval covered by this long-range forecast of visibility zones. On the first date of this chart, apogee height is about 650 miles, perigee about 125. Based on orbital elements for September 30th, this chart extends the one on page 624 of the October issue, where the caption explains the arrows and dots.

Simplified Prediction Manual

A METHOD for predicting the passages of satellites from modified orbital elements has been devised by three agencies that are co-operating in the IGY effort. It is described in a manual entitled *Simplified Satellite Prediction from Modified Orbital Elements,* written by Leonard N. Cormier, Norton Goodwin, and Reginald K. Squires, and published by the National Academy of Sciences-National Research Council.

The authors believe that from both the computation and communication standpoints, the transmission of orbital elements to the observer offers the simplest, most concise arrangement. They believe the observer is then more likely to receive up-to-date information in sufficient time to be conveniently useful.

However, many observers are unfamiliar with the computation of orbits. In this manual is presented a scheme whereby a set of modified orbital elements may be handled by anyone who can do arithmetic. In well-prepared schedules, each step of the operation is precisely stated, while space is provided for completing the calculations on the forms.

The procedure permits an observer to "(a) eliminate all but potentially significant observation periods; (b) for any such period, determine the precise time when the satellite will cross (or approach) his latitude circle, the longitude of the crossing (or approach), and the satellite height; and (c) derive from such crossing (or approach) data the azimuth, elevation, and slant range to the satellite for one or more optical observations, or comparable data for radio observations."

The authors have attained the desired simplicity through extensive use of prepared tables and charts which occupy more than half of the 46-page monograph. Even if one prefers algebraic and trigonometric formulae, some of the tables will be useful. In the opinion of this writer, the only real shortcoming of the method is that the angular position of low satellites during close approaches is not given very accurately on the small-scale charts.

The draft edition of the manual, together with 10 short and 30 long computing forms, may be obtained for one dollar a copy from the National Academy of Sciences-National Research Council, 2101 Connecticut Ave., N.W., Washington 25, D. C.

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OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Early Observations of Mars

THIS MONTH the planet Mars will be better placed for telescopic observation than at any other time until 1971. In early June, 1969, the planet will be about as close to the earth as this November, but far south of the celestial equator and therefore low in the sky for most observers in the Northern Hemisphere.

Mars comes to opposition with the sun this November 16th, but least distance from the earth, 45.4 million miles, occurs eight days earlier. In 1956 the closest approach was 35.2 million miles, on September 7th.

This year Mars at its nearest will show a disk 19.2 seconds of arc in diameter, compared with 24.8 in 1956. But its declination will be $+19\frac{1}{2}°$, as against $-10°$ then, placing Mars about 30° higher when on the meridian for Northern Hemisphere observers. This increased altitude will hardly compensate, however, for the disk diameter being 22 per cent less.

Good telescopes of small aperture will show the larger orange deserts and dark "seas" of Mars, but at least a 6-inch telescope is needed for observation of finer details. Most students of Mars agree that a first-rate 10-inch telescope reveals considerably more detail visually than do the best photographs.

From my more than 23 years of observing experience, I have found little difference between good reflectors and good refractors of equal aperture. On nights of better than average seeing, reflectors usually provide better image contrast, with sharpness equal to that in refractors. With only fair seeing, refractors have somewhat steadier and prettier images, but with subdued contrast.

To see much of the Martian surface

Thomas R. Cave, Jr., made these drawings with an 8-inch Newtonian reflector using powers from 360 to 450. For each is given the 1958 date, UT, seeing (0-to-10 scale), Martian diameter and central-meridian longitude: 1, June 21, 11:30, 5-6, 8″.1, 302°. 2, Aug. 3, 9:30, 7, 10″.4, 204°. 3, Aug. 8, 9:00, 5-7, 10″.7, 153°. 4, Aug. 17, 9:00, 7-8, 11″.3, 42°. 5, Aug. 21, 8:00, 6-9, 11″.7, 13°. 6, Aug. 27, 8:00, 6-8, 12″.2, 316°. 7, Aug. 29, 8:20, 4-7, 12″.3, 287°. 8, Sept. 1, 8:00, 5-6, 12″.4, 261°. 9, Sept. 4, 8:00, 5-7, 12″.9, 241°.